UNMANNED AERIAL VEHICLES

1994

MASTER PLAN

DEPARTMENT OF DEFENSE

PREFACE

The Unmanned Aerial Vehicles (UAV) Joint Project Office was officially established in response to Congressional direction by a charter signed by the Director of Defense Research and Engineering on 16 October 1989. It is the single Department of Defense organization charged with management responsibility for UAVs. The United States Navy was designated as the Executive Service for nonlethal UAV programs, and the UAV project was assigned to what is now the Program Executive Officer for Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project and staffed by officers from all Services. Congress also directed that the Department of Defense submit an annual UAV Master Plan. This 1994 UAV Master Plan is the sixth submission to Congress. It provides the acquisition and technology strategies, management, and program plans for nonlethal UAVs. Lethal UAVs are addressed in the classified Department of Defense Standoff Weapons Master Plan.

This Master Plan is structured into three parts: an Executive Summary, a main body of 10 sections providing extensive detail, and an appendix of supporting material including discussions of dual uses of UAVs and UAV civil airspace management issues.

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ACRONYMS (Executive Summary)

ACTD	Advanced Concept and Technology Demonstration
APU	Auxiliary Power Unit
ARPA	Advanced Research Projects Agency
CARS	Common Automatic Recovery System
C&I	Commonality and Interoperability
CEP	Concept Evaluation Program
CONOPS	Concept of Operations
COTS	Commercial-off-the-Shelf
CR	Close Range
DAB	Defense Acquisition Board
DARO	Defense Airborne Reconnaissance Office
DT	Developmental Test
EO	Electro-Optical
FLIR	Forward Looking Infrared
FLOT	Forward Line of Own Troops
FY	Fiscal Year
GCS	Ground Control Station
GFE	Government Furnished Equipment
HAE	High Altitude Endurance
HFE	Heavy Fuel Engine
IOT&E	Initial Operational Test and Evaluation
JII	Joint Integration Interface
JORD	Joint Operational Requirements Document
JPO	Joint Project Office
JT	Joint Tactical
JTC/SIL	Joint Technology Center/Systems Integration Laboratory
JUAVT	Joint UAV Team
LHD	Landing Helicopter-Dock
LPD	Landing Platform-Dock
MAE	Medium Altitude Endurance
MAVUS	Maritime VTOL UAV System
MORR	Maturation and Operational Risk Reduction
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OT	Operational Test
RAM	Reliability, Availability and Maintainability
SAR	Synthetic Aperture Radar
SR	Short Range
TRUS	Tilt Rotor UAV System
UAV	Unmanned Aerial Vehicle
UAV JPO	Unmanned Aerial Vehicle Joint Project Office
US	United States
USA	United States Army
USMC	United States Marine Corps
USN	United States Navy
VLAR	Vertical Launch and Recovery
VTOL	Vertical Takeoff and Landing

1993 IN RETROSPECT

1993 was an eventful year for the Unmanned Aerial Vehicles (UAV)* Joint Project Office (JPO). The UAV joint management concept is paying dividends. Many significant accomplishments occurred in 1993, including:

- The Short Range (SR) UAV was approved for limited production by the Defense Acquisition Board (DAB)
- The first production contract for SR was awarded. SR replaces Pioneer as it is phased out of the inventory
- Pioneer installations were completed in two landing platform-dock (LPD) class ships
- Pioneer completed successful deployments in Somalia and Bosnia aboard the LPDs and received praise from operational commanders in both theaters of operation
- Began deliveries of Pioneer air vehicles to replace those lost in Desert Storm, permitting recovery of inventory
- A readiness improvement program for Pioneer was initiated to sustain its assets through the decade
- A successful demonstration of the SR UAV aboard the USS Essex, a landing helicopter-dock (LHD) class ship, was completed in December. Plans are now underway for accelerated fielding of this capability as the eventual replacement for Pioneer
- The low cost Pointer Hand Launched and EXDRONE UAVs participated in numerous demonstrations, exercises, and evaluations. Such activities provide field users initial, hands-on experience with UAVs and the opportunity to develop employment concepts at low cost
- The Maritime Vertical Takeoff and Landing UAV System (MAVUS II) demonstration program completed tether testing and land based testing in preparation for an at-sea demonstration aboard the USS Vandegrift (FFG-48) now underway
- Initial flight testing was completed with the Tilt Rotor UAV System (TRUS), a Congressionally directed vertical take off and landing (VTOL) UAV technology demonstration
- An over-arching, generic engineering specification for development, called the UAV Capstone Specification, was completed
- International data exchange agreements were executed with Israel, Germany, and the Netherlands
- On the Government management side, the previously separate Short and Close Range (CR) Project Offices were merged and streamlined into a new single office called the Joint Tactical (JT) Project Office with responsibility for the Hunter UAV (previously known as SR), the Shipboard Variant of Hunter, the Maneuver Variant UAV (previously known as CR), and all related ground support equipment. Numerous other accomplishments and details of those described above are contained in Sections 2 through 9.

The responsibilities of the UAV JPO grew in 1993. We were given the management responsibility for the Medium Altitude Endurance (MAE) UAV advanced concept and technology demonstration (ACTD) program. Additionally, discussions were underway at the end of the year for the UAV JPO to have a significant role in the Advanced Research Projects Agency (ARPA) lead program for a High Altitude Endurance (HAE) UAV. However, our progress did not prevent the UAV JPO

* Acronyms are defined when first used in the text. Appendix G defines acronyms used more than once in the text. Additionally, the inside cover of each Section defines most acronyms used in that Section.

from coming under criticism in the fiscal year 1994 (FY94) Senate Armed Services Committee Report largely for lack of progress in fielding systems. The primary purpose of this year's Master Plan is to let everyone know that "we got the message." This Master Plan will address the Congressional concerns and emphasize management initiatives that:

- Intimately involve the military user
- Reduce fielding risks of UAV systems
- Explain more clearly implementation of UAV system commonality and interoperability (C&I).

The Defense Airborne Reconnaissance Office (DARO) UAV Program Plan has preceded the publication of this UAV Master Plan. DARO is the new organization within the Office of the Secretary of Defense (OSD) charged with oversight responsibility for all tactical airborne reconnaissance, manned and unmanned. The DARO UAV Program Plan presents UAVs in this more global framework, while the UAV JPO Master Plan is more focused on our plan to address user, fielding, and C&I issues. The management relationships between DARO and the UAV JPO are discussed in Section 1, Management.

1994 OBJECTIVES

Building on our 1993 accomplishments, the major objectives of the UAV JPO in 1994 are:

- Implement a Maturation and Operational Risk Reduction (MORR) phase for Hunter
- Continue a Block II upgrade for heavy fuel engine (HFE) development and integration for the Hunter UAV
- Procure as government furnished equipment (GFE), integrate, and test a common automatic recovery system (CARS) for the Hunter UAV and its Shipboard Variant
- Procure the common and downsized hardware for the Maneuver Variant
- Execute a readiness improvement program for Pioneer and integrate Pioneer on additional LPD-class ships
- Award the prime contract and payload contract for the MAE. (Note: the contracts have been awarded). Deliver three air vehicles and one ground control station (GCS)
- In conjunction with ARPA, the program manager, develop and initiate the acquisition strategy for the HAE
- Complete the Concept Evaluation Program (CEP). Continue demonstrations with military and non-military users of the Pointer Hand Launched UAV
- Procure and field two EXDRONE systems for operational use
- Complete the at-sea operational demonstration of MAVUS II
- Complete the TRUS technical flight demonstrations and initiate additional demonstrations as part of the Vertical Launch and Recovery (VLAR) program
- Execute demonstrations of new UAV payloads on Pioneer and the Hunter UAVs.

Additional objectives are addressed in Sections 2 through 9.

LONG RANGE PLANS

The UAV JPO's long range (1995-1999) planning objectives are summarized below. Future budgets based on these objectives must be part of the yearly Presidential Budget Submit, and must be authorized and appropriated by Congress.

- Fully field the JT UAV System
- Complete testing and integration of a CARS capability for the JT UAV System

- Complete HFE and other block upgrades in the JT UAV System
- Procure the Maneuver Variant air vehicle and complete the integration efforts based on an approved joint operational requirements document (JORD)
- Complete the program and field a limited MAE capability
- Execute the acquisition strategy for a HAE capability
- Use the low cost Pointer Hand Launched and EXDRONE UAVs to respond to limited military user needs for demonstrations, training, and fielding, and to foster the dual use aspects of UAVs with paramilitary and civilian organizations
- Complete and verify all the joint integration interfaces (JIIs) and UAV family architecture
- Execute a program of enhanced payload demonstrations that satisfy user needs
- Use the Joint Technology Center/ Systems Integration Laboratory (JTC/SIL) to support expanded use of UAV simulation and modeling, payload integration, and verification of operational and production improvements
- Stimulate and demonstrate technology for UAV collision avoidance; wing deicing; small, heavy fuel auxiliary power units (APUs); advanced VTOL concepts; and other improvements
- Field a common UAV training simulator device capability
- Exploit international and dual uses of air vehicles, payloads, and UAV technologies for the benefit of the US industrial base.

UAV FAMILY CONCEPT

The foundation to achieving the management initiatives addressed in the last subsection is a UAV family concept with the JT UAV Program as the baseline and centerpiece. Figure ES-1 illustrates this concept (see next page). The top bar identifies the categories of mission needs in terms of distances from the forward line of own troops (FLOT) or own force position in naval terms. See Appendix A for a detailed discussion of mission needs. The middle bar identifies the UAV air vehicles that will address the mission needs. The JT UAV Program includes the Hunter, Shipboard Variant, and Maneuver Variant air vehicles that address the CR and SR mission needs. Just as important, this baseline program maximizes commonality among subsystems: payloads, launch and recovery, data links, mission planning and control, and logistics. Additionally, endurance air vehicles will employ these common subsystems as they mature. The lower bar identifies operational and technical demonstrations that provide growth potential and satisfy special needs. Low cost UAVs provide users the opportunity to get hands-on UAV experience and exploit concept development. In some cases they can satisfy special needs for expendable or "scout" UAV capabilities. VTOL UAVs address both naval and land forces' desires for UAVs that have minimal launch and recovery space needs. The MAE and HAE provide the basis for satisfying endurance air vehicle requirements.

USER INVOLVEMENT

It is imperative that the user be "onboard" and fully supportive of the UAV family concept. To achieve this, the UAV JPO maintains intimate involvement with the user community throughout the acquisition life cycle of UAVs. In this role the UAV JPO provides:

- Analysis, advice, and recommendations that assist in the development of operational requirements documents (ORDs) and concepts of operations (CONOPS)
- Commercial-off-the-shelf (COTS) UAV systems for demonstrations and exercises that permit the user to develop CONOPS and determine minimum levels of required performance
- Opportunities for early user involvement and

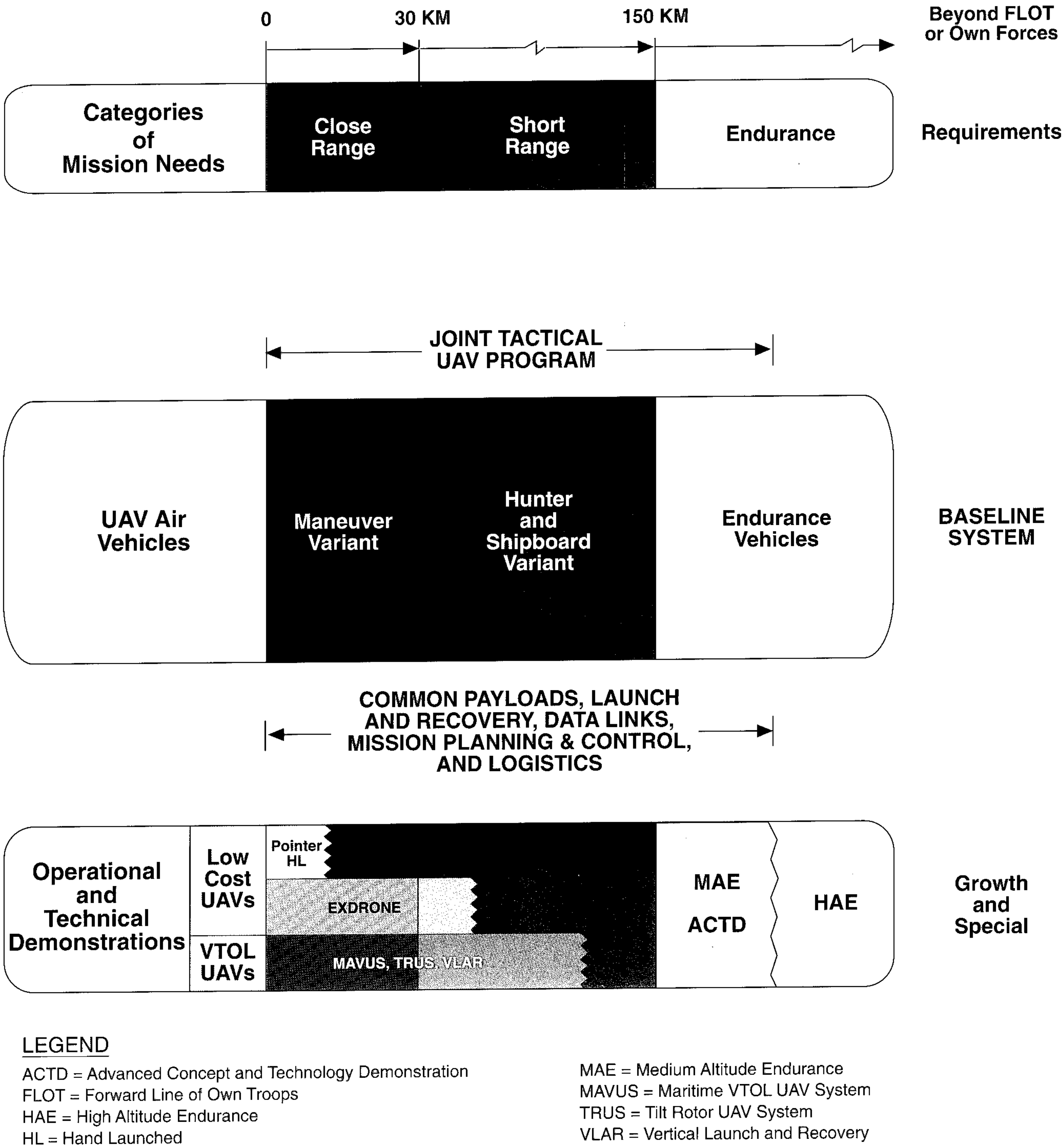


Figure ES-1 UAV Family Concept

feedback prior to and during developmental testing (DT)

- Support during user operational testing (OT)
- Development of training concepts and training for fielding new systems
- Full logistics support for fielded systems.

Section 2 provides details of UAV JPO involvement with US Army (USA), US Navy (USN), and US Marine Corps (USMC) users. Examples include:

- Enhance operational effectiveness by exploring tactics, techniques, and procedures prior to actual fielding of the Hunter UAV to tactical units
- Development of a Joint Training Facility for use in training USA, USN, and USMC operation and maintenance personnel
- Conduct of a shipboard demonstration with the USN to verify the feasibility of operating a Hunter UAV from an LHD-class ship at sea
- Use of prototyping and demonstrations with multiple users during MAE UAV system development to evaluate new technologies and CONOPS
- Use of the EXDRONE system to refine and validate the Maneuver Variant requirements, as well as to develop UAV command and control procedures, airspace coordination, and unit standard operating procedures
- Encouragement of a COTS acquisition strategy with the Pointer Hand Launched UAV system in order to support rapid fielding in the event of a formal requirement, as well as direct customer feedback to the contractor.

FIELDING

A MORR phase has been added to the Hunter Program to reduce the risk associated with IOTE, shorten the IOTE and address Congressional concerns. The addition of this phase causes a slight delay in Milestone III but maintains an event driven Hunter acquisition strategy.

The system maturation will expand the development test data and evalutation while providing higher reliability, availability, and maintainability (RAM) confidence through increased operating hours. This will allow for verification of the logistics support system and improvements in the man-machine compatibility. The operational effectiveness will be enhanced by allowing the user to refine the warfighting doctrine and verifying the adequacy of the force structure. During this phase the command and control interfaces will also be proved out. IOT&E currently contains testing in an alternate environment. This requirement may be able to be satisfied by a field exercise in an alternate environment during the MORR phase which would shorten IOT&E.

The addition of the MORR phase also addresses Congressional concerns such as testing in an unrealistic environment and the system acquisition being schedule driven.

The Maneuver Variant of the JT UAV Program will be fielded in FY97. Since the JT UAV Program is the baseline for the family of UAVs, the Maneuver Variant uses the majority of the hardware and software developed for the Hunter UAV. Since only the air vehicle and some downsized hardware has to be developed for the Maneuver Variant, this strategy has eliminated the need for a separately managed and developed program. The Maneuver Variant UAV is a product improvement or block upgrade of the JT UAV System.

The MAE UAV is to be fielded as an ACTD in 1996. In early January 1994, General Atomics, San Diego, CA was selected as the prime contractor for this effort within 40 days of program authorization. The system provides 24-hour on-station capability at over 500 miles from the launch point with nonline-of-sight capability through a satellite link. In 30 months, 10 air vehicles and 3 GCSs will be fielded with both electro-optical (EO)/ forward-looking infrared (FLIR) and synthetic aperture

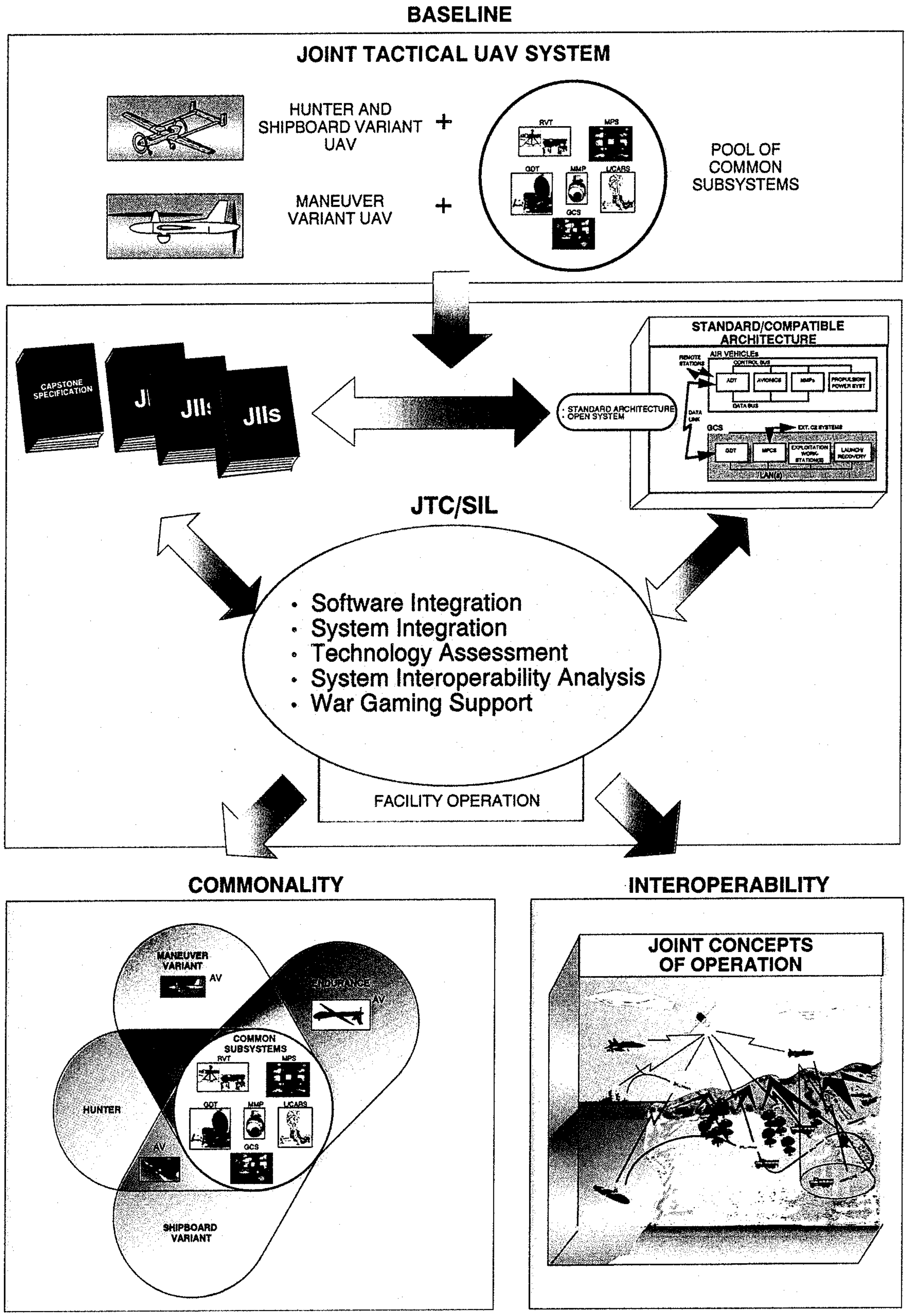


Figure ES-2 UAV C&I Building Blocks

radar (SAR) payload sensor capabilities. Section 3 provides detailed discussions of UAV programs and demonstrations.

COMMONALITY AND INTEROPERABILITY

C&I is an engineering management process employed by the UAV JPO to field a family of UAV systems that are as identical as possible and can seamlessly operate with other appropriate elements of the joint and allied battleforce architecture. It is a process that, on one hand, must be opportunistic and flexible in nature to achieve commonality both now and with future technology and, on the other hand, rigorous and disciplined to achieve interoperability within the family of UAVs and with a myriad of other battleforce systems.

The fundamental building blocks of the C&I process are:

- A hardware and software system foundation based on the JT UAV system
- A standard and open system architecture that facilitates hardware and software changes across interface boundaries
- A top level system engineering structure embodied in the UAV Capstone Specification
- A set of interface parameters, called JIIs, that provide disciplined control of system boundaries
- A structured laboratory environment, the JTC/SIL, where simulation and engineering tools can be employed to test, verify, modify, and expand hardware and software elements of the UAV family and related systems.

Figure ES-2 illustrates the C&I building blocks, while Section 4 provides a detailed discussion and many additional illustrations of how the C&I process is implemented.

STRATEGIES EMPLOYED

In order to implement the management initiatives addressed previously the UAV JPO operates and executes programs within the framework of strategy elements described below:

- Assure that Service and Unified Command operational requirements are joint, identical where possible, and harmonized to the maximum extent if they cannot be identical
- Involve the Services' users early and continuously in a program's life
- Provide the Services demonstrator UAVs and UAV technologies to gain hands-on operational experience. This experience is essential for developing CONOPS and minimum levels of required performance
- Employ competition at the system and subsystem level
- Procure COTS and government-off-the-shelf (GOTS) technologies and components for initial systems
- Be the catalyst and driving force to achieve commonality and joint Service and allied acceptance among UAV system hardware and software, testing, training, and logistics support
- Improve fielded UAVs through incremental technology upgrades of subsystems
- Use risk reducing demonstrations of new UAV technology to speed the introduction of improvements
- Stimulate exploratory and advance technology development that has the potential to enhance future UAV performance and affordability
- Maintain control of system and subsystem hardware and software interfaces so that interoperability can be achieved within the family of UAVs and with other elements of US and allied battleforce architecture

STRATEGY ELEMENTS	Examples	Addressed in Section
Assure that Service and Unified Command operational requirements are joint, identical where possible, and harmonized to the maximum extent if they cannot be identical	Joint Tactical UAV Program, Medium Altitude Endurance (MAE), High Altitude Endurance (HAE)	2, 3
Involve the Services' users early and continuously in a program's life	Joint Tactical UAV Program, MAE, HAE, Pointer Hand Launched, EXDRONE	2, 3
Provide the Services demonstrator UAVs and UAV technologies to gain hands-on operational experience. This experience is essential for developing concept of operations (CONOPS) and minimum levels of required performance	Pioneer, Pointer Hand Launched, EXDRONE, Maritime VTOL UAV System (MAVUS) II, Payloads	2, 3, 5
Employ competition at the system and subsystem level	Joint Tactical UAV Program, MAE, Tilt Rotor UAV System (TRUS), Vertical Launch and Recovery (VLAR) System, Heavy Fuel Engine (HFE)	3, 5
Procure commercial-off-the-shelf (COTS), and government-off-the-shelf (GOTS) technologies and components for initial systems	Joint Tactical UAV Program, Pointer Hand Launched, MAE, VLAR, Payloads	3, 5
Be the catalyst and driving force to achieve commonality and joint Service and allied acceptance among UAV system hardware and software, testing, training and logistics support	Joint Tactical UAV Program, HFE, Common Automatic Recovery System (CARS), Modular Integrated Avionics Group (MIAG), Common Data Link	3, 5
Improve fielded UAVs through incremental technology upgrades of subsystems	Pioneer, Joint Tactical UAV Program	3
Use risk reducing demonstrations of new UAV technology to speed the introduction of improvements	Shipboard Variant, TRUS, Pointer Hand Launched, VLAR, MAVUS	3
Stimulate exploratory and advanced technology development that has the potential to enhance future UAV performance and affordability	Joint Technology Center/Systems Integration Laboratory (JTC/SIL), UAV Payload Demonstrations	4, 5, 6
Maintain control of system and subsystem hardware and software interfaces so that interoperability can be achieved within the family of UAVs and with other elements of United States (US) and allied battleforce architecture	Capstone Specification, Joint Integration Interfaces (JIIs), JTC/SIL, Data Exchange Agreements (DEAs)	4, 7, 9
Employ modeling and simulation to develop CONOPS and initial technical specifications and to reduce testing and training costs	Pointer Hand Launched Training Simulator, Survivability/Vulnerability Information Analysis Center (SURVIAC), Training Simulator	3, 4, 6, 7
Develop and execute a coherent international UAV program that encourages allied partnerships and sharing of technology	DEAs, Scientist and Engineer Exchange Programs, international cooperation, demonstrations, and standardization efforts	9
Foster dual-use civil and commercial applications of UAVs to achieve cost savings and strengthen the US industrial base	Pioneer, Pointer Hand Launched, HFE, Small Business Innovation Research (SBIR)	3, 5 Appendix C

Table ES-1 Strategy Elements Guide

- Employ modeling and simulation to develop CONOPS and initial technical specifications, and to reduce testing and training costs

- Develop and execute a coherent international UAV program that encourages allied partnerships and sharing technology

- Foster dual-use civil and commercial applications of UAVs to achieve cost savings and strengthen the US industrial base.

Table ES-1 ties the framework of strategy elements to specific examples and to detailed discussions provided in the main body of this Master Plan.

SYSTEM FIELDING AND QUANTITIES

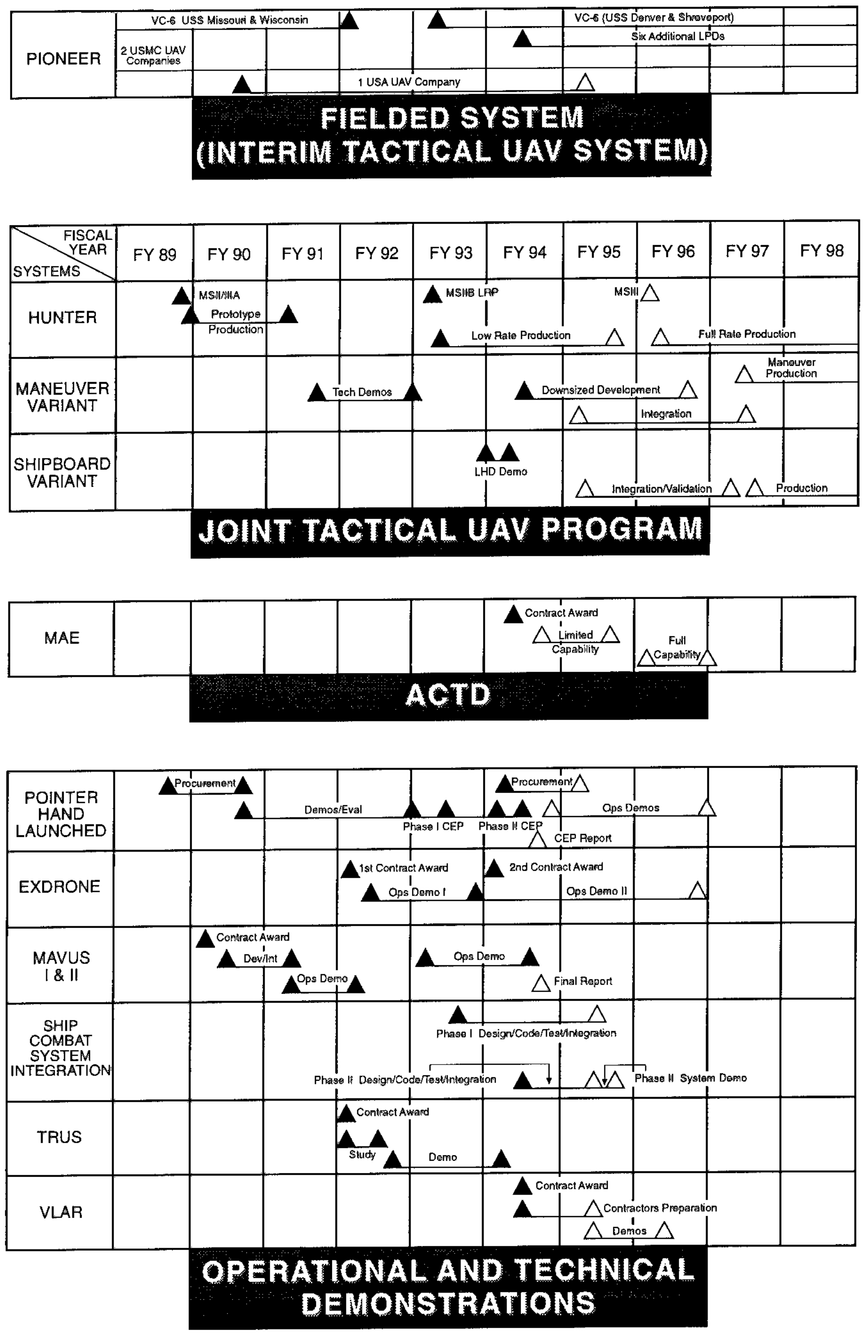
Table ES-2 provides fielding and system quantity information for each program and demonstration.

MASTER SCHEDULE

Figure ES-3 (on page ES-10) provides the Master Schedule for UAV programs and demonstrations.

PROGRAM/ DEMONSTRATION	FIELDED	QUANTITY
JOINT TACTICAL UAV PROGRAM		
Hunter	4th Quarter 1994	32 Systems
Maneuver Variant	3rd Quarter 1997	100 Systems
Shipboard Variant	2nd Quarter 1997	18 Systems
Pioneer	USN (2) USA (1) USMC (3)	6 Systems Fielded 3 Support Systems
MAE	ACTD	10 Air Vehicles 3 GCSs
Pointer Hand Launched	Operational Demonstration	8 Systems
EXDRONE	Operational Demonstration	5 Systems
MAVUS I&II	Operational Demonstration	1 System
TRUS	Technical Demonstration	2 Air Vehicles
VLAR	Technical Demonstration	TBD

Table ES-2 Fielding and System Quantities



LEGEND

ACTD = Advanced Concept and Technology Demonstration
CEP = Concept Evaluation Program
DEV/INT = Develop/Integrate
LHD = Landing Helicopter-Dock
LPD = Landing Platform-Dock
LRP = Low Rate Production
MAE = Medium Altitude Endurance
MS = Milestone
R&D = Research and Development
RFP = Request for Proposal
TRUS = Tilt Rotor UAV System
VLAR = Vertical Launch and Recovery
UAV = Unmanned Aerial Vehicle

Figure ES-3 UAV Master Schedule as of 31 May 1994

ACRONYMS (Section 1)

ARPA	Advanced Research Projects Agency
C^3I	Command, Control, Communications and Intelligence
C&I	Commonality and Interoperability
CR	Close Range
CSC	Conventional Systems Committee
DAB	Defense Acquisition Board
DARO	Defense Airborne Reconnaissance Office
DoD	Department of Defense
DUSD(AT)	Deputy Under Secretary of Defense for Advanced Technology
EXCOM	Executive Committee
JROC	Joint Requirements Oversight Council
JT	Joint Tactical
MAE	Medium Altitude Endurance
NSA	National Security Agency
OSD	Office of the Secretary of Defense
PEO(CU)	Program Executive Officer, Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project
SR	Short Range
SSG	Special Study Group
UAV	Unmanned Aerial Vehicle
UAV JPO	Unmanned Aerial Vehicle Joint Project Office
USD(A)	Under Secretary of Defense (Acquisition)
USN	United States Navy

1.1 MANAGEMENT

In response to congressional direction in FY88 to consolidate the management of Department of Defense (DoD) nonlethal UAV programs, the Under Secretary of Defense (Acquisition) (USD(A)) established the UAV JPO. An Executive Committee (EXCOM) was established with overall responsibility for DoD UAV programs at the OSD level. In 1991 the EXCOM oversight was discontinued, and DoD UAV programs were brought under DAB procedures and management as described in DoD Directive 5000.1 and DoD Instruction 5000.2. Figure 1-1 shows the UAV management organization.

The USN is the Executive Service for the UAV Joint Project, which is part of the Program Executive Office, Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project (PEO(CU)). The UAV JPO has responsibility and accountability for designing, developing, procuring, and transitioning UAV systems to the Services. The systems must meet the requirements validated by the Joint Requirements Oversight Council (JROC) commensurate with available funding. The DAB and Conventional Systems Committee (CSC) maintain oversight, provide program direction, and approve milestones for UAV programs. The UAV Working Group conducts acquisition-related activities in support of the DAB and CSC. Chaired by OSD Command, Control, Communications and Intelligence (C^3I), the working group includes representatives of the DAB and CSC, plus the National Security Agency (NSA), ARPA, UAV JPO and other designated elements of OSD and Service staffs.

The JROC reviews all deficiencies that may lead to a major system development, determines the validity of mission needs, and participates in the validation of key parameters found in the performance section of acquisition program baselines prior to DAB reviews. The JROC UAV Special Study Group (SSG) is responsible for consolidating and reconciling requirements before presenting them to the JROC

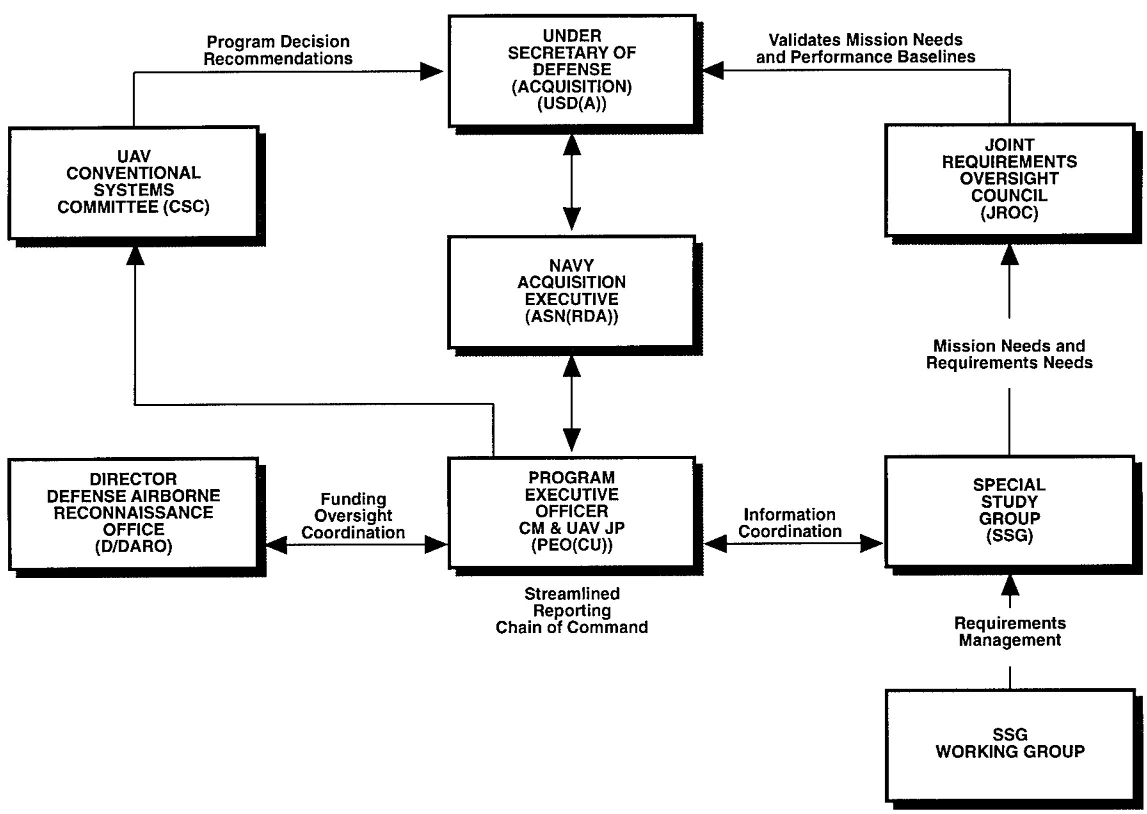


Figure 1-1 UAV Management Organization

for approval. Working groups support the SSG. One working group has responsibility for UAVs in general and another working group deals specifically with UAV payloads. The UAV JPO confers with the working groups and the SSG to resolve requirements-related issues.

In 1993 the DARO was established by the Deputy Secretary of Defense on 6 November 1993 under the Deputy Under Secretary of Defense for Advanced Technology (DUSD(AT)) to provide oversight and guidance to all airborne reconnaissance efforts, including the UAV JPO. Funding and oversight for UAV JPO projects is provided through the DARO organization as shown in Figure 1-2. The UAV JPO is chartered by DoD to be the central manager for all system development and acquisition programs for nonlethal UAVs. The UAV JPO manages the conduct of advanced UAV technology demonstrations and concept exploration programs.

The UAV JPO is a small, lean, customer-oriented organization composed of five functional Directorates and four program offices (including aerial targets, which are not addressed in this document). See Figure 1-3. To reduce overhead costs, the SR and CR Program Offices were consolidated into the single JT UAV Project Office. Additionally, programs such as the MAE and the Pointer Hand Launched UAV are managed by the Directorates rather than having separate program offices.

The purpose of the UAV JPO is to manage C&I among UAV system hardware and software, testing, training, and technology and logistics support. The UAV JPO maintains a continuous, close relationship with the user community throughout all phases of the acquisition life cycle.

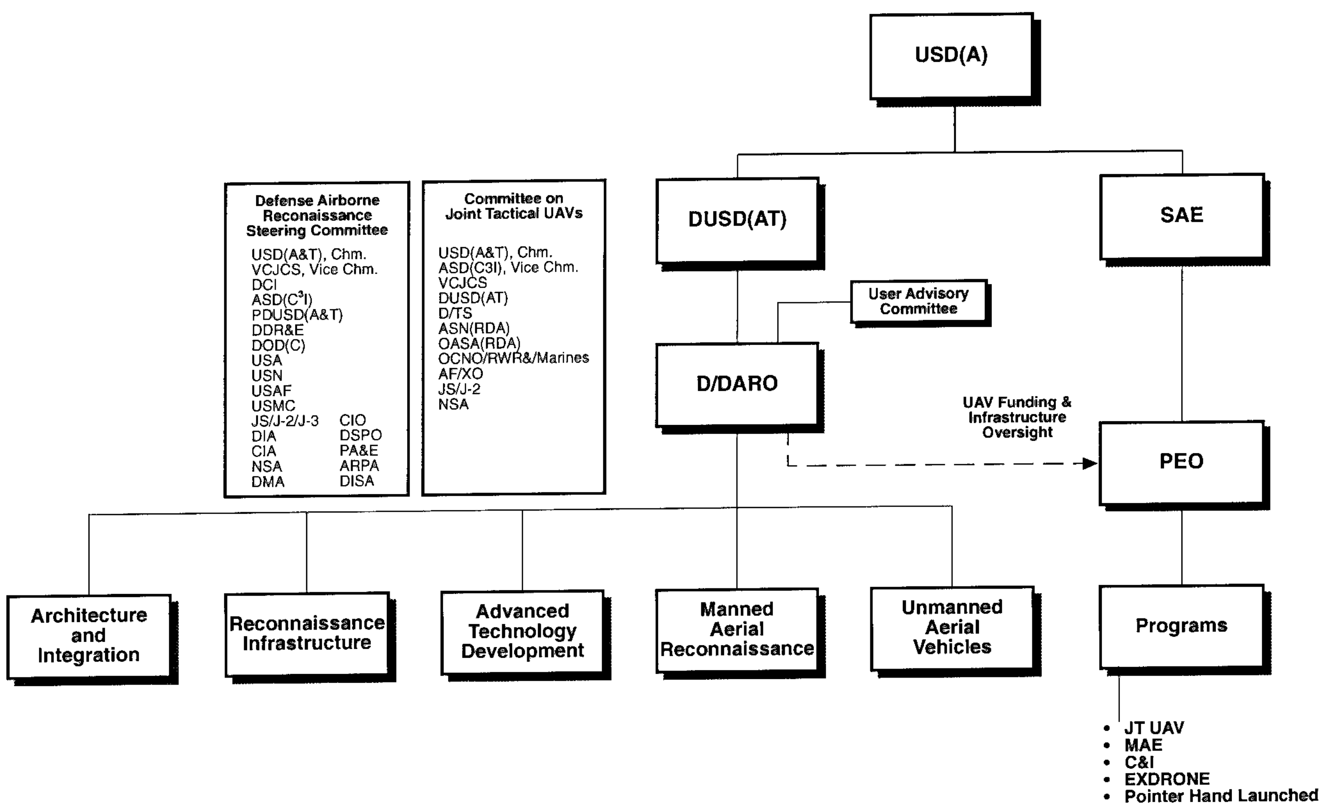


Figure 1-2 Funding and Infrastructure Oversight

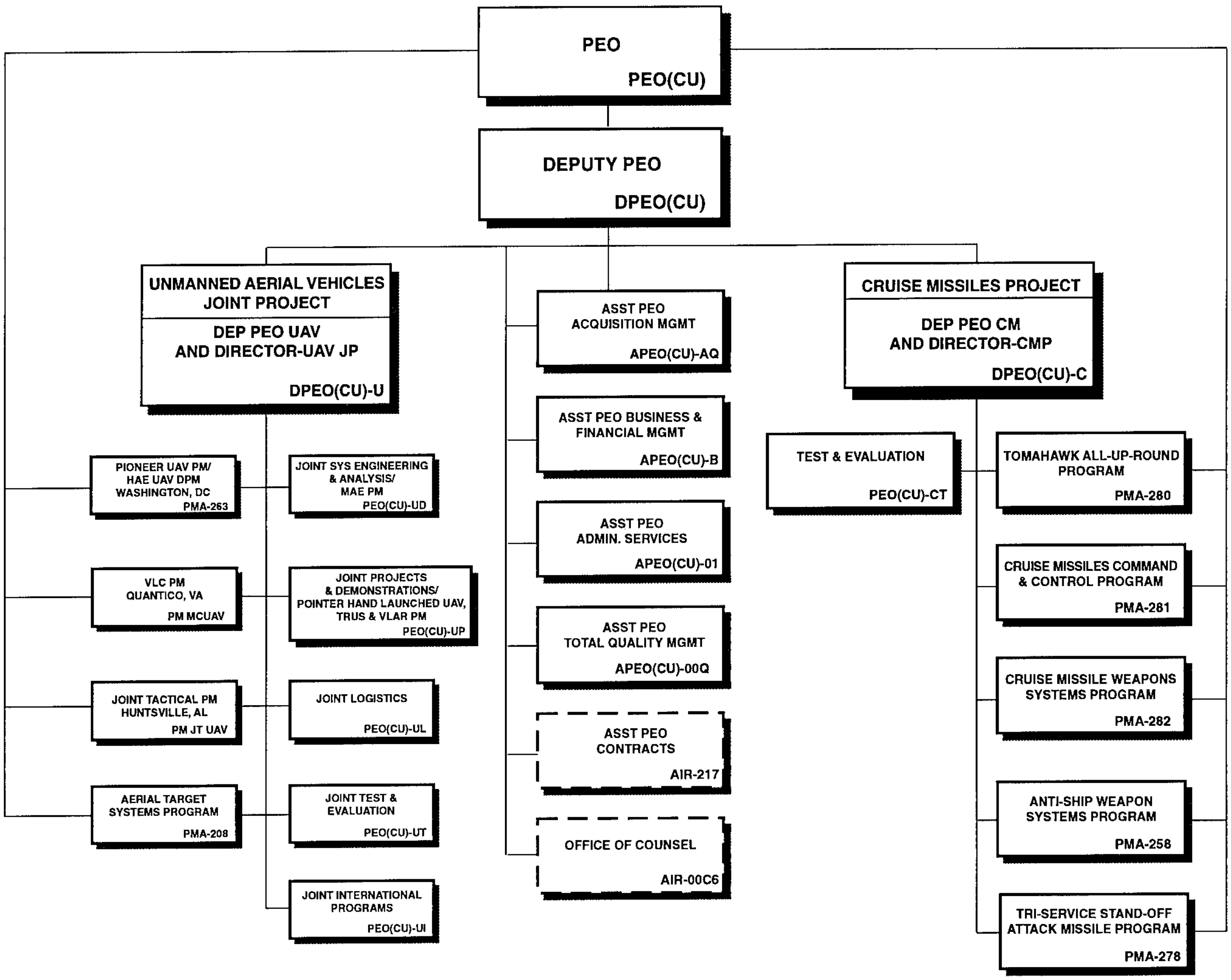


Figure 1-3 PEO(CU) Organization

ACRONYMS (Section 2)

ACTD	Advanced Concept and Technology Demonstration
BDA	Battle Damage Assessment
CAX	Combined Arms Exercises
CEP	Concept Evaluation Program
COMOPTEVFOR	Commander, Operational Test and Evaluation Force
CONOPS	Concept of Operations
COTS	Commercial-off-the-Shelf
DoD	Department of Defense
DT	Developmental Test
DUTC	DoD UAV Training Center
EOA	Early Operational Assessment
FAST	Fleet Assistance Support Team
FY	Fiscal Year
HQDA	Headquarters Department of the Army
IFF	Identification, Friend or Foe
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
JRTC	Joint Readiness Training Center, Ft Polk, LA
JUAVT	Joint UAV Team
LHD	Landing Helicopter-Dock
LPD	Landing Platform-Dock
MAE	Medium Altitude Endurance
MAVUS	Maritime VTOL UAV System
MCCDC	Marine Corps Combat Development Command
MNS	Mission Need Statement
MORR	Maturation and Operational Risk Reduction
MSL	Mean Sea Level
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NBC	Nuclear, Biological and Chemical
NGB	National Guard Bureau
NTC	National Training Center, Ft Irwin, CA
ONS	Operational Need Statement
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OT	Operational Test
RATO	Rocket Assisted Takeoff
RPV	Remotely Piloted Vehicle
TRADOC	Training and Doctrine Command
UAV	Unmanned Aerial Vehicle
UAV JPO	Unmanned Aerial Vehicle Joint Project Office
USA	United States Army
USMC	United States Marine Corps
USN	United States Navy
VTOL	Vertical Takeoff and Landing
WTI	Weapon Tactics Instruction

The UAV JPO is a customer-oriented organization. It is focused to support its customer, the operational user, continuously throughout the UAV system life cycle. The UAV JPO provides the user community "one stop shopping" for all their needs including, but not limited to:

- Analysis, advice, and recommendations that assist in the development of ORDs and CONOPS
- COTS UAV systems for demonstrations and exercises that permit the user to develop CONOPS and determine minimum levels of required performance
- Opportunities for early user involvement in DT
- Support during user OT
- Support for early fielding opportunities
- Development of training concepts and training for fielding of new systems
- Full logistics support for fielded systems.

The following discussions address UAV JPO user-related activities.

2.1 PIONEER

2.1.1 Fleet Assistance and Support Team

The fleet assistance support team (FAST) is a USMC organization located at Pt. Mugu, CA. The FAST has one Pioneer remotely piloted vehicle (RPV) system with four air vehicles assigned. It provides test and evaluation support for acceptance testing of new air vehicles and the resolution of operational problems experienced by Pioneer RPV units in the field. The FAST also supports developmental tests of new equipment and test support/data collection during exercises conducted by both DoD and non-DoD units. Throughout 1993, FAST Pioneer RPVs provided video coverage for 11 fleet missile shots from surface ships and submarines. From January to April 1993, Pioneer was used to test the Alternate Band Datalink and Mode "C" identification, friend or foe (IFF) system. This effort is required before UAVs can fly in commercial air space without chase planes. From late July to late September 1993, they also conducted test flights of the Coastal Battlefield Reconnaissance payload, which consists of two cameras that view the same target area at different wavelengths. Comparing the two images reveals areas in which the soil was disturbed and where mines may have been laid. In early January 1994, the FAST participated in the National Aeronautics and Space Administration (NASA) Portable Automatic Triggering equipment test in which the air vehicles were used to measure the pressure wave differential that occurs during a sonic boom.

2.1.2 USMC RPV Companies

The USMC has three operational units equipped with Pioneer RPV systems. The 1st UAV Company is located at Twentynine Palms, CA and has one Pioneer system with five air vehicles assigned. The 1st UAV Company participated in four combined arms exercises (CAX) in 1993. A CAX is a simulated exercise using both air and ground assets that teach units with different functions how to work effectively together. The company was also involved in a Weapon Tactics Instruction (WTI) and a Marine Air Group exercise. The 3rd UAV Company, also located at Twentynine Palms, CA, has one Pioneer system with five air vehicles. The 3rd UAV Company participated in Exercise TEAM SPIRIT 1993 in Korea, one CAX, and four unit local training exercises. The 2nd UAV unit is located at Jacksonville, NC. It participated in an exercise at the Joint Readiness Training Center (JRTC), Ft. Polk, LA, a WTI, and a Supporting Arms Tactical Exercise, which is a demonstration for flag rank officers that shows the capability of each of the USMC assets in its current inventory.

2.1.3 Training, Ft. Huachuca

The DoD UAV Training Center (DUTC) is located at Ft. Huachuca, AZ and has one Pioneer system with five air vehicles assigned. DUTC provides initial training for personnel from all Services in the operation and maintenance of the Pioneer system. In 1993, DUTC trained 12 USA, 43 USMC, 19 USN, and 9 civilian personnel.

2.1.4 VC-6 (USS Shreveport and USS Denver)

The Fleet Composite Squadron Six Detachment Patuxent River (VC-6 Det Pax) is the only USN operational unit equipped with the Pioneer system. VC-6 UAV Det Foxtrot (a part of VC-6 Det Pax) is assigned to the USS Shreveport (LPD-12) with one Pioneer system with five air vehicles. The unit deployed in August 1993 and participated in two sea-based operations en route to the Indian Ocean. The detachment conducted 11 flights in support of Operation Continue Hope until early November 1993. It participated in Exercise Bright Star with the Egyptians and subsequently supported Adriatic operations. During this deployment, the Pioneer clearly demonstrated that the system is a valued asset for a variety of missions. VC-6 UAV Det Golf deployed on the USS Denver (LPD-13) from the

West Coast in early September 1993. In October 1993, it relieved Det Foxtrot in Operation Continue Hope. Det Foxtrot has flown 37 flights for 199.7 flight hours, and Det Golf has flown 27 flights for 66.6 flight hours through March 1994.

Pioneer operations aboard LPD-class ships involve rocket assisted takeoff (RATO) launch and net recovery with the shipboard Pioneer arresting recovery system, which requires modification of the ship for installation. Only two ships are presently modified, but there are plans to modify six additional LPD-class ships in the near future to handle Pioneer RPV operations.

2.1.5 USA

The USA has one operational Pioneer-equipped unit, UAV Company C, located at Fort Huachuca, AZ. UAV Company C is assigned one Pioneer RPV system with five air vehicles. This company participated in Exercise TEAM SPIRIT 1993 in Korea, unit training at the White Sands Missile Range, NM, an exercise at the JRTC, and a CAX at the National Training Center (NTC), Ft. Irwin, CA.

2.2 JOINT TACTICAL UAV SYSTEM

2.2.1 Training, Ft. Huachuca

The training program for the Hunter UAV is under development at Ft. Huachuca, AZ. In 1993, the system contractor began delivery of training documents to the government for review and validation. The training program is being established now so that it can be evaluated during the IOT&E scheduled for 1995. Instructor and key personnel training is scheduled to begin in May 1994 at Ft. Huachuca; the first training class for Ft. Hood personnel is scheduled for October 1994.

A JUAVT has been established at Ft. Huachuca to support fielding of the Hunter UAV. The USA Intelligence Center and School will perform the materiel development assessment function. Materiel development efforts are also tied into future operational concepts. During the assessment, the Intelligence Center coordinates with other Training and Doctrine Command (TRADOC) Battle Labs, other Services and DoD agencies, and other program managers to minimize any duplicative effort and maximize benefits of available technology. The TRADOC Battle Lab process is critical to the successful integration of new technologies and systems into the active force inventory. All future requirements are validated in the Battle Labs prior to initiation of the acquisition procurement cycle. The Battle Labs assess the utility of the system and the impact on force structure and doctrine. Using various venues (including the Louisiana Maneuvers and Joint Precision Strike Demonstration), doctrine, tactics, techniques, and procedures are worked and evaluated.

During the MORR phase in FY95, the JUAVT will provide a mechanism for exploration of tactics, techniques, and procedures prior to actual fielding to tactical units. Field exercises are planned during MORR. UAV capabilities are being demonstrated to warfighting commanders and integrated into their intelligence collecting and targeting architectures. The JUAVT supports the Joint Precision Strike ACTD. Some payload demonstrations will be accomplished in coordination with materiel developers. Additionally, documentation activity is ongoing such as technical manual verification and validation and the logistics support analysis record process, which are essential to successful fielding.

A UAV Joint Training Facility (see Figure 2-1) is currently under construction at Ft. Huachuca, AZ. Construction began on 19 January 1993. When complete in July 1994, this 42,000 square foot facility will include 22 classrooms, a computer simulation room, a high bay, a hazardous material storage area, and 5 laboratories for use in training USA, USN, and USMC UAV operator and maintenance personnel.

Every effort is being made to keep the troops in the loop during development and fielding. The users are actively involved in the operational tempo demonstration to assess human factors and validate and verify the Operational Mode Summary/Mission Profile for the Hunter

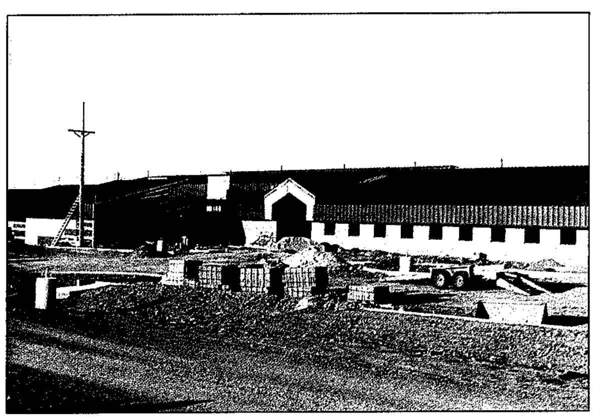


Figure 2-1 UAV Joint Training Facility

UAV. The operational tempo demo is conducted to determine the adequacy of manning levels for the Hunter UAV and to assess personnel, hardware and software capabilities. This demo stresses the system while providing continued, intensive mission support. Also, the Hunter UAV is being used in the MORR phase to enhance user tactics and doctrine prior to a full production decision. In cooperation with the USN, a shipboard demonstration was conducted in December 1993 to verify the feasibility of Hunter UAV operations from an LHD-class ship. Use will be made of field training exercise opportunities to involve the user, to demonstrate the capabilities of the Hunter UAV, and to obtain the users' endorsement. By working hand-in-hand with the user, the testing agencies are able to observe user/system interface, verify achievement of observable performance and support objectives and expedite the testing process. The Hunter UAV, if directed by national command authority, now has the capability to respond to limited intensity conflicts such as Desert Shield/Storm, Somalia, or Bosnia. For the future, the user is a key player in the definition and prioritization of future payload requirements such as electronic warfare, radar, weather, and nuclear, biological and chemical (NBC) reconnaissance, mine detection, and communications operations planning through OSD special study groups.

2.2.2 Shipboard Variant Demonstration Onboard USS Essex

In December 1993, an initial Shipboard Variant capability demonstration was successfully conducted onboard the USS Essex (LHD-2) (see Figure 2-2). The demonstration accumulated 8 hours and 27 minutes of flight time including 10 low-altitude shipboard passes (10-50 ft), 24 touch and go landings, 7 arrested landings, 4 shipboard launches (3 deckrun and 1 RATO), and video downlink distribution. Flights included takeoff from land-based sites with shipboard recovery and vice versa. All ship emitters were activated and directed toward the air vehicle as it was towed down the deck (with air vehicle engines running and all air vehicle systems and ground equipment powered up); there was no interference to the air vehicle controls, only minimum video downlink static. The air vehicle demonstrated no susceptibility to the electromagnetic environment while in flight. During air vehicle flight, all ship emitters (except the AN/SPS-48, AN/SPS-49, and MRC 23 TAS) were evaluated for electromagnetic effects on the shipboard system. The system demonstrated no degradation of downlink or other adverse system response. The effects of AN/SPS-48, AN/SPS-49, and MRC 23 TAS emissions were not evaluated during air vehicle flight due to schedule conflicts. The USS Essex demonstration showed that the Hunter is compatible with the amphibious assault ship flight deck; showed that takeoffs, landings, and deck maneuvering can be conducted safely; and helped establish the initial air vehicle operating envelope. The lessons learned from the demonstration have provided a basis for system/ship interface and configuration analysis through 1994, integration and testing in 1995, and installation of the first system in 1996 for Fleet evaluation and subsequent 1997 initial operational capability (IOC).

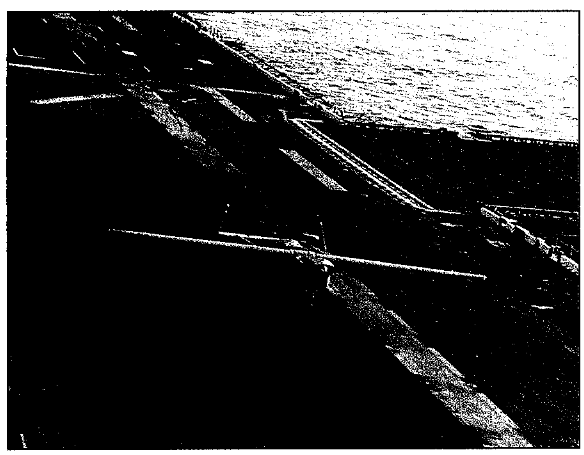
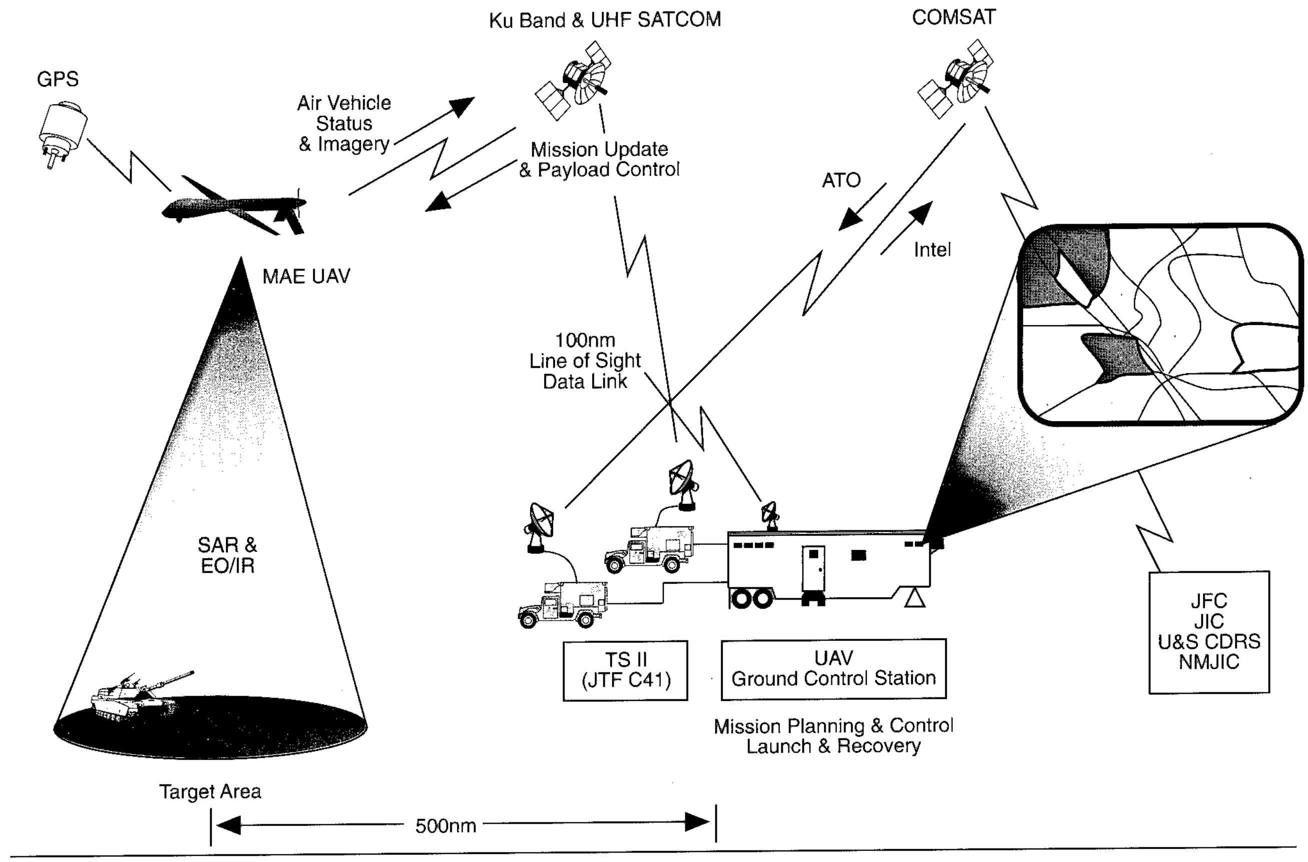


Figure 2-2 USS Essex Shipboard Demonstration

2.3 MEDIUM ALTITUDE ENDURANCE (MAE)

The MAE UAV program has been selected to develop a 15,000 ft above mean sea level (MSL) class UAV. The MAE UAV is one of eight programs selected for an ACTD. Under the ACTD concept, the MAE UAV system will use prototyping and demonstrations with multiple users to evaluate a concept of operations and new technologies. During the ACTD, the MAE UAV will be tested with multiple users, which will result in an operational concept that reflects potential users' future operational employments. The users' requirements will be incorporated into the CONOPS development at the very earliest stages by this iterative approach. Figure 2-3 pro-



LEGEND

ATO = Air Tasking Order
COMSAT = Communications Satellite
GPS = Global Positioning System
EO/IR = Electro-Optical/Infrared
JFC = Joint Force Commander

JIC = Joint Intelligence Center
JTF = Joint Task Force
MAE = Medium Altitude Endurance
nm = Nautical Miles
NMJIC = Naval Maritime Joint Intelligence Center

SAR = Synthetic Aperture Radar
SATCOM = Satellite Communications
TS II = Trojan Spirit Two
U&S CDRS = Unified and Specified Commander
UHF = Ultra High Frequency

Figure 2-3 MAE UAV CONOPS

vides a CONOPS for the MAE UAV to be used in initial demonstrations.

2.4 CL-227 SENTINEL (USS Doyle and USS Vandegrift)

In 1990, a project agreement was signed between the Canadian and US Governments for a cost-sharing technical demonstration of MAVUS. MAVUS I was the first phase of the program and culminated in an at-sea demonstration onboard the USS Doyle (FFG-39) from 12 October through 11 December 1991. It was installed on the USS Doyle for use during a Standing Naval Force Atlantic deployment with other North Atlantic Treaty Organization (NATO) participants. Seven flights were conducted using four air vehicles. One air vehicle was lost. An early operational assessment was conducted and determined that a rotary wing VTOL UAV system could be operationally effective in the areas of naval gunfire support, as a source of video for rebroadcast to force elements, as an electronic decoy platform, in conducting battle damage assessments (BDAs), and in minimizing detection during reconnaissance.

On 28 May 1993, the contract was awarded for the second phase of MAVUS development (MAVUS II) with costs to be shared by both the US and Canadian Governments. Essentially, it is a basic MAVUS I system with the addi-

tion of an automated launch and recovery system integrated for the hands-off launch and recovery of the air vehicle aboard a small naval combatant.

The MAVUS II system was installed on the USS Vandegrift (FFG-48) in San Diego, CA in February 1994. The system will become an integral part of the ship's combat system and will be operated and evaluated by the ship's crew throughout the scheduled demonstration period (March through May 1994). Representatives from the Commander, Operational Test and Evaluation Force (COMOPTEVFOR) will be onboard to continue the early operational assessment (EOA) initiated during the MAVUS I program.

2.5 EXDRONE

This very low cost UAV has demonstrated its potential in the family of UAVs as a reconnaissance air vehicle. An early version of the EXDRONE was used by the USMC during Desert Storm to conduct reconnaissance over Iraqi positions. During the 100 hours of flight time in the operation, the EXDRONE demonstrated a capability to conduct combat reconnaissance over high-risk areas. Since Desert Storm, the EXDRONE system has been used to refine and validate the Maneuver Variant (CR) requirements. It has also been used to develop UAV command and control procedures, airspace coordination, air tasking, and development of unit standard operating procedures.

The EXDRONE system has participated in 7 major exercises, completed more than 300 mission flights, and now has over 500 hours of flight time. During field demonstrations, the system has been used successfully to conduct surveillance operations, route reconnaissance, and artillery adjustment.

2.5.1 USMC

The 2nd Marine Division has been very successful in its use of the EXDRONE system. In July 1993, the Marine Corps Combat Development Command (MCCDC) stated a requirement for four EXDRONE systems in FY94. The systems will be used in further development of Maneuver Variant CONOPS. These systems are in production with the first system to be delivered to the user in May 1994.

2.5.2 USA

The EXDRONE system has been used in extended field demonstrations with the USA 101st Air Assault Division, 24th Infantry Division, and USA III Corps. The III Corps and the 101st Air Assault Division continue to train with the EXDRONE system and to refine their procedures for operations with a Maneuver Variant capability. They have used the system extensively for developing their current operating procedures.

2.6 POINTER HAND LAUNCHED UAV

Early, continuous, and extensive user involvement with an operational emphasis has been the hallmark of the Pointer Hand Launched UAV demonstration program since its inception in 1989. A COTS acquisition strategy to support rapid fielding in the event of a formal requirement has been consistently emphasized, taking advantage of integrating new technologies as they mature in the commercial market. The UAV JPO has also encouraged system design changes via direct customer feedback to the contractor, while insisting on keeping the system simple in practice.

2.6.1 USA

USA evaluation of the Pointer Hand Launched UAV concept using the Pointer UAV accelerated in 1993. Following successful deployments to the NTC by units of the 1st Cavalry Division, the Commanding General, USA III Corps submitted an operational need statement (ONS) for 30 Pointer systems to equip III Corps brigades. This ONS was subsequently validated only for III Corps requirements by Headquarters, Department of the Army (HQDA). Furthermore, HQDA authorized Commander, USA Forces Command to expend command funds to acquire, train, maintain, and operate the Pointer systems. As a result of this initial evaluation, a Phase II CEP conducted by the USA Mounted Warfighting Battlespace Lab has been initiated. The goal of the CEP is to determine if there is a USA-wide requirement for a hand launched UAV and to define the characteristics of this system in a validated mission need statement (MNS) and ORD.

2.6.2 National Guard

In addition to the USA, the National Guard Bureau (NGB) conducted an extensive operational evaluation of the Pointer Hand Launched UAV in 1993. Beginning in February 1993, the Oregon National Guard flew eight operational missions in Oregon and Washington in support of various law enforcement missions. Most of the missions were in support of counterdrug efforts or illegal gambling detection. Funding constraints required termination of the Oregon National Guard evaluation program in December 1993, but follow-on evaluation with the New Mexico National Guard is anticipated in 1994.

ACRONYMS (Section 3)

ACTD	Advanced Concept and Technology Demonstration
ADT	Air Data Terminal
AMGSS	Air Mobile Ground Security System
ATWCS	Advanced Tomahawk Weapons Control Station
BDA	Battle Damage Assessment
C^2	Command and Control
C^3I	C^2, Communications & Intelligence
C^4I	C^3, Computers & Intelligence
C&I	Commonality & Interoperability
CARS	Common Automatic Recovery System
CARS-P	Common Automatic Recovery System Prototype
CDL	Common Data Link
CDR	Critical Design Review
CEP	Concept Evaluation Program
COEA	Cost and Operational Effectiveness Analysis
COMINT	Communications Intelligence
COMOPTEVFOR	Commander, Operational Test and Evaluation Force
CONOPS	Concept of Operations
COTS	Commercial-off-the-Shelf
DAB	Defense Acquisition Board
DEA	Drug Enforcement Agency
DESA	Defense Evaluation Support Activity
DUSD(AT)	Deputy Under Secretary of Defense for Advanced Technology
DUTC	DoD UAV Training Center
DWBL	Dismounted Warfighting Battlespace Lab
ELINT	Electronics Intelligence
EO	Electro-Optical
EW	Electronic Warfare
EXCOM	Executive Committee
FAST	Fleet Assistance Support Team
FLIR	Forward Looking Infrared
FLOT	Forward Line of Own Troops
GCS	Ground Control Station
GDT	Ground Data Terminal
GFE	Government Furnished Equipment
GPS	Global Positioning System
HAE	High Altitude Endurance
HFE	Heavy Fuel Engine
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
IR	Infrared
JROC	Joint Requirements Oversight Council
JRTC	Joint Readiness Training Center, Ft Polk, LA
JTF	Joint Task Force
LAMPS	Light Airborne Multipurpose System
LRIP	Low Rate Initial Production
LUT	Limited User Test
MAE	Medium Altitude Endurance
MAGTF	Marine Air-Ground Task Force
MAVUS	Maritime VTOL UAV System
MCCDC	Marine Corps Combat Development Command
MMP	Modular Mission Payload
MNS	Mission Need Statement
MOA	Memorandum of Agreement
MPCS	Mission Planning and Control Station
MSL	Mean Sea Level
MST	Manned Surrogate Trainer
MWBL	Mounted Warfighting Battlespace Lab
NAWC-AD	Naval Air Warfare Center - Aircraft Division
NBC	Nuclear, Biological and Chemical
NGB	National Guard Bureau
NRaD	Naval Command, Control, and Ocean Surveillance Center RDT&E Division
NTC	National Training Center, Ft Irwin, CA
ONS	Operational Need Statement
ORD	Operational Requirements Document
P^3I	Pre-Planned Product Improvement
PS	Prototype Ship
PSEMO	Physical Security Equipment Management Office
RATO	Rocket Assisted Takeoff
RCS	Radar Cross Section
RDT&E	Research, Development, Test and Evaluation
RFI	Request for Information
RPV	Remotely Piloted Vehicle
RSTA	Reconnaissance, Surveillance and Target Acquisition
SAR	Synthetic Aperture Radar
SCSI	Ship Combat System Integration
SDT	Ship Data Terminal
SIGINT	Signals Intelligence
SIL	Systems Integration Laboratory
STV	Surrogate Teleoperated Vehicle
TET	Technical Evaluation Test
TRADOC	Training and Doctrine Command
TRSS	Tactical Remote Sensor System
TRUS	Tilt Rotor UAV System
UGV	Unmanned Ground Vehicle
USACERL	USA Corps of Engineers Construction Engineering Research Laboratory
USD(A)	Under Secretary of Defense (Acquisition)
VLAR	Vertical Launch and Recovery
VTOL	Vertical Takeoff and Landing
WTI	Weapon Tactics Instruction

This Section discusses UAV programs, which include the following:

- JT UAV Program (the centerpiece program for the family of UAVs)
- Pioneer (a fielded system)
- Demonstrations (ACTDs, operational, and technical)
- Medium Range (MR) UAV (a recently terminated program).

Figure 3-1 below illustrates that the Hunter UAV is the baseline for achieving C&I across the family of UAVs.

3.1 JOINT TACTICAL UAV PROGRAM

3.1.1 Background

On 17 December 1993, the JT UAV Project Office was established to consolidate the SR, the CR, and the marinized SR requirements into a single system under one program manager. The program will consist of the Hunter UAV (formerly SR), the Maneuver Variant (formerly CR), and the Shipboard Variant (SR marinized). The Hunter UAV is the baseline of the JT UAV system. This consolidation ensures common architecture and interoperability. The overall UAV system provides the USA, USN, and USMC commanders with near real-time reconnaissance, surveillance and target acquisition (RSTA) support. The Hunter UAV provides ground commanders with sustained, deep RSTA support designed to meet USA Division, Corps, Theater, and all levels of Marine Air-Ground Task Forces (MAGTF) requirements. Potential growth payloads (see para 3.1.3) provide added capabilities beyond the initial RSTA capability. The Maneuver Variant includes downsized, portable equipment capable of rapid deployment and is designed to operate in the forward battle areas providing direct support to maneuver battalions and brigades. The Shipboard Variant provides similar capabilities in support of USN task forces. All variants within the JT UAV system will be interoperable with the baseline system.

Acquisition of the Hunter UAV began in FY89 with full and open competition resulting in the award of two firm-fixed price contracts on 15 September 1989. On 16 February 1990, the UAV JPO was awarded the Navy Action Plus Excellence Award for FY89 in the Acquisition Streamlining Program Manager Category. After extensive technical evaluation testing (TET) and limited user testing (LUT), a prime contractor was downselected on 30 June 1992, just 33 months after program initiation. The prime contract was awarded to the Israel Aircraft Industries, Tel Aviv, Israel and TRW, San Diego, CA (IAI/TRW) team;

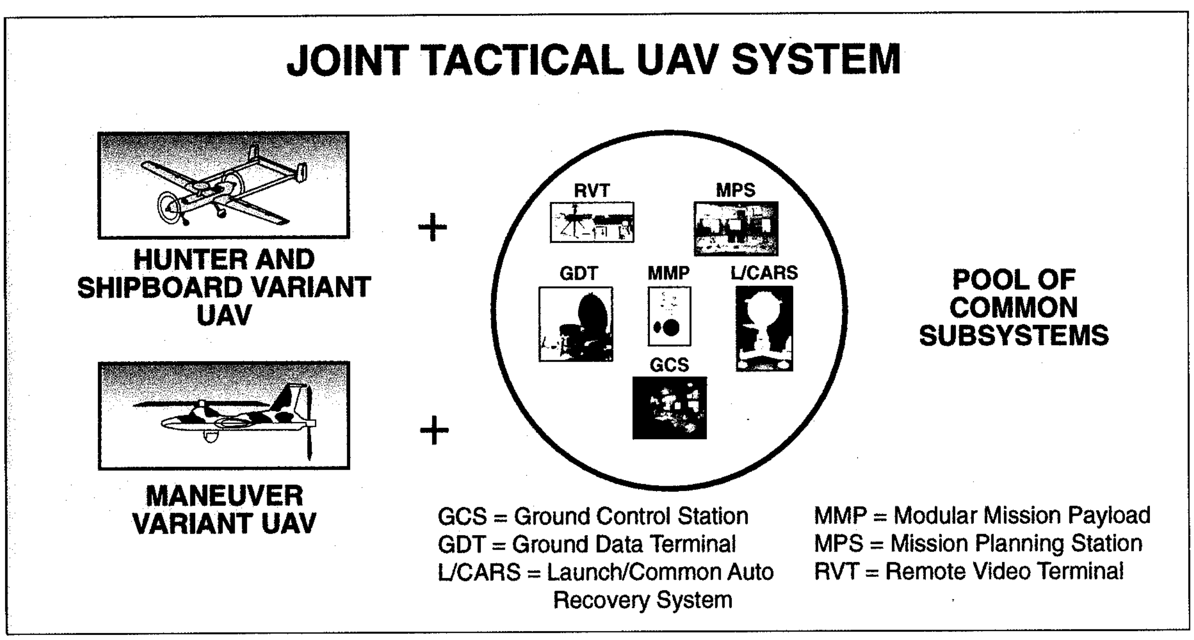


Figure 3-1 Hunter UAV is the Baseline System for Commonality & Interoperability

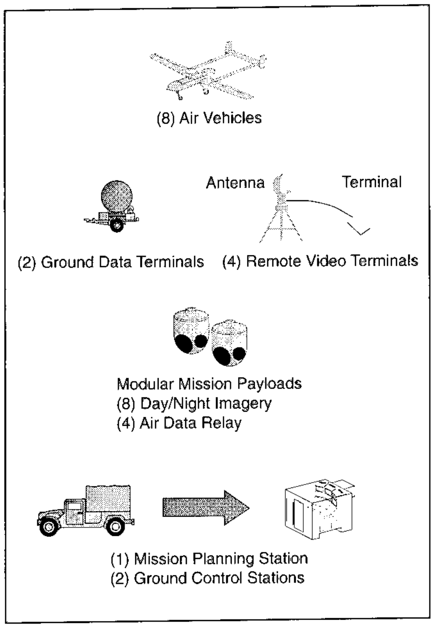


Figure 3-2
Hunter UAV Description

subsequent arrangements made TRW the prime contractor instead of IAI. A DAB review was held on 19 January 1993 and approved the program for low rate initial production (LRIP), block enhancements, acquisition strategy, and exit criteria.

3.1.2 Purpose

Hunter

The Hunter UAV is used for gathering and transmitting near real-time information for USMC, USN, and USA battle commanders. It flies missions up to 8 hours in duration, out to 150 km beyond the FLOT, day or night, and in limited adverse weather conditions. Figure 3-2 displays the subsystem elements. Hunter UAV is intended for employment in environments where immediate information feedback is needed, manned aircraft are unavailable, or excessive risk or other conditions render use of manned aircraft less than prudent.

Maneuver Variant

The Maneuver Variant UAV is being developed for high threat, close-in missions out to 30 km beyond the FLOT, day or night, to support lower echelon maneuver units, and provides a cost-effective alternative to the Hunter UAV in that environment. The Maneuver Variant UAV will be significantly cheaper than the Hunter UAV and will meet the deployability, mobility, and flexibility requirements suitable for the maneuver combat units of the USA and USMC. All components of the Maneuver Variant (see Figure 3-3) are to be two-person transportable. The MNS for CR (now called Maneuver Variant), approved by the JROC on 17 January 1990, established the need for a lower echelon, real-time RSTA, electronic warfare (EW), target designation, and NBC reconnaissance capability.

3.1.3 Concept of Operations

Hunter

The Hunter UAV is required to provide USA and USMC forces near real-time imagery intelligence with a radius of action of 200 km. The system will be transported on C-130 or larger aircraft (such as C-141, C-17, and C-5). The air vehicles will be operated from unim-

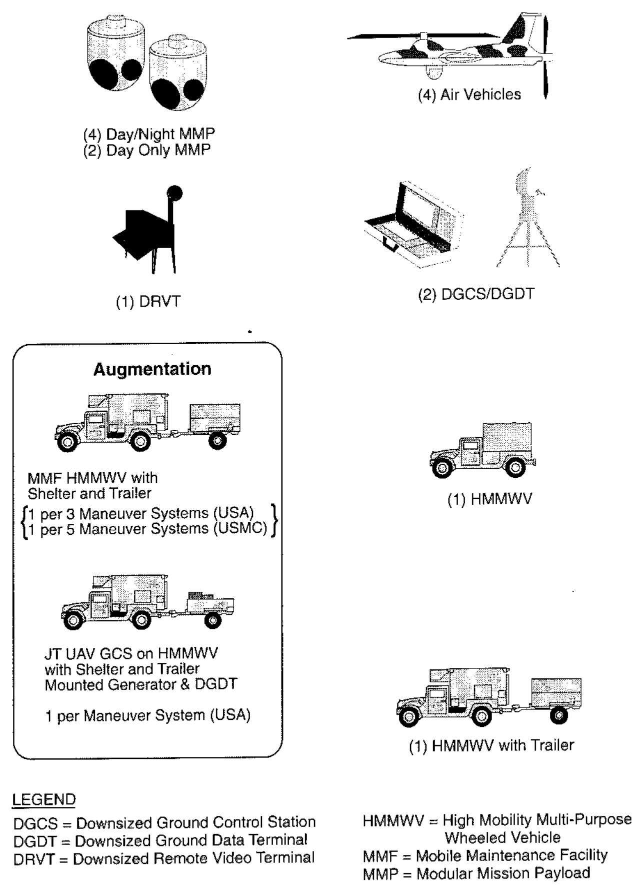


Figure 3-3 Maneuver Variant Description

proved, short runway areas and will have RATO capability. Launch, recovery, and handling operations, including mission planning, will be accomplished in rear areas by theater, corps, or division USA intelligence units. For the USMC, the Hunter UAV is soon to be in the UAV Company of the USMC surveillance, reconnaissance, and intelligence group and will be in direct or general support of all levels of MAGTFs. The Hunter UAV CONOPS is shown in Figure 3-4. After mission planning and preflight operations, two air vehicles are launched: a relay air vehicle and a mission air vehicle. The relay air vehicle is usually positioned in an orbit behind the FLOT. The mission air vehicle is positioned in preplanned orbit areas beyond the FLOT and will send intelligence data to the relay air vehicle. The relay air vehicle will then relay the intelligence data to the GCS. The relay air vehicle will also send mission control data from the GCS to the mission air vehicle. This setup directs the mission air vehicles to target areas for more precise target identification. High-value target information is processed to appropriate Service fire support and intelligence networks. The Hunter UAV provides the battlefield commanders with RSTA intelligence an average of 16 hours for every 24 hour period. This capability allows the battlefield commanders to see far beyond the FLOT without placing personnel in harm's way. In addition to the RSTA intelligence data gathering capability, the modular mission payload (MMP) concept allows for future growth in the Hunter's capabilities. Potential air vehicle payloads (interchangeable with the initial day/night payload) include:

- Moving target indicator
- Electronics intelligence (ELINT)
- Electronic countermeasures/ Decoys
- Communications intelligence (COMINT)
- Communications jammers
- Laser designator/range finder
- Mine detection
- SAR
- NBC sensor
- Non-communications jammers
- Communications data/relay

Figure 3-4 Hunter UAV CONOPS

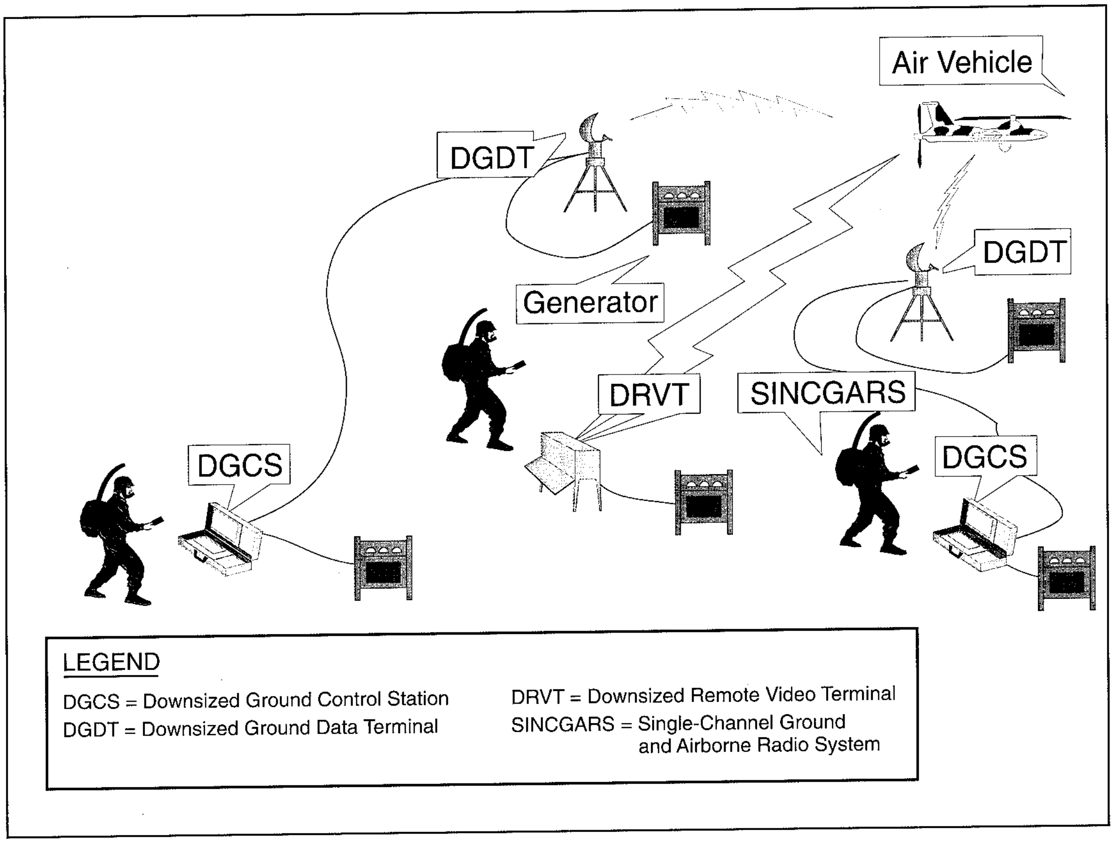


Figure 3-5 Maneuver Variant CONOPS

- Psychological operations.

A plan for demonstration of payloads is provided in Section 5.2. A table of characteristics for the Hunter UAV is in Appendix B.

Maneuver Variant

The diversion of divisional Hunter assets to support USMC and USA brigade-level UAV requirements significantly reduces Hunter effectiveness at division level. In addition, given the sharply reduced UAV ranges required for brigade operations, dedicated brigade Hunter assets are not cost effective, and the size of the Hunter with its support equipment precludes deployment with early entry forces. With the capability to transport one baseline system on board one C-130 aircraft, the Maneuver Variant UAV provides improved deployability beyond that provided by Hunter. A less expensive, smaller air vehicle provides adequate coverage with significantly less ground support equipment, providing tailored UAV support commensurate with the operational flexibility, deployability, and supportability essential for operations in the forward battle area. Figure 3-5 represents the concept of operations for the Maneuver Variant.

The joint Service UAV requirements for brigade and light division support are:

- Near-real time intelligence out to 30 km beyond the FLOT
- Independent system operational capability for 72 hours on no more than two high mobility multi-purpose wheeled vehicles and one trailer
- Two-person transportable equipment; no more than a six-person crew
- Confined launch and recovery capability.

The reduced crew size, coupled with the

capability to conduct operations close to the FLOT and sustain operations with minimal support provide brigades and light divisions with effective support at significantly reduced life-cycle cost. A table of characteristics for the Maneuver Variant is found in Appendix B.

Shipboard Variant

A table of characteristics for the Shipboard Variant is in Appendix B. Maritime capable systems are to be deployed aboard landing helicopter-assault (LHA) and LHD amphibious ships and aircraft carriers (CV and CVN). Basic mission areas include amphibious warfare, RSTA, over the horizon classification and targeting, naval surface fire support, and BDA. Figure 3-6 displays the CONOPS for the Shipboard Variant.

Each system will be installed as an integral part of the ship's weapons/sensor suite and will consist of eight air vehicles, two GCSs and one mission planning station located in combat/intelligence spaces, four remote video terminals, two launch and recovery terminals, and two ground data terminal (GDT) antennas mounted aloft. The Shipboard Variant will be supported by a deployable UAV detachment and provide continuous presence in all theaters.

The elements of the Shipboard Variant are shown in Figure 3-7 (see next page).

3.1.4 Acquisition Strategy

Hunter

A competitive nondevelopmental acquisition strategy has been followed in the Hunter UAV acquisition. A market survey, numerous meetings with industry representatives, and a draft request for proposal (RFP) confirmed the feasibility of the strategy and refined its terms to conform to Government needs and realistic technical expectations. A full and open competition was initiated from which two contractors with the most promising systems were selected. Firm fixed priced contracts were awarded to each contractor to build two systems in 18 months and deliver them to the Gov-

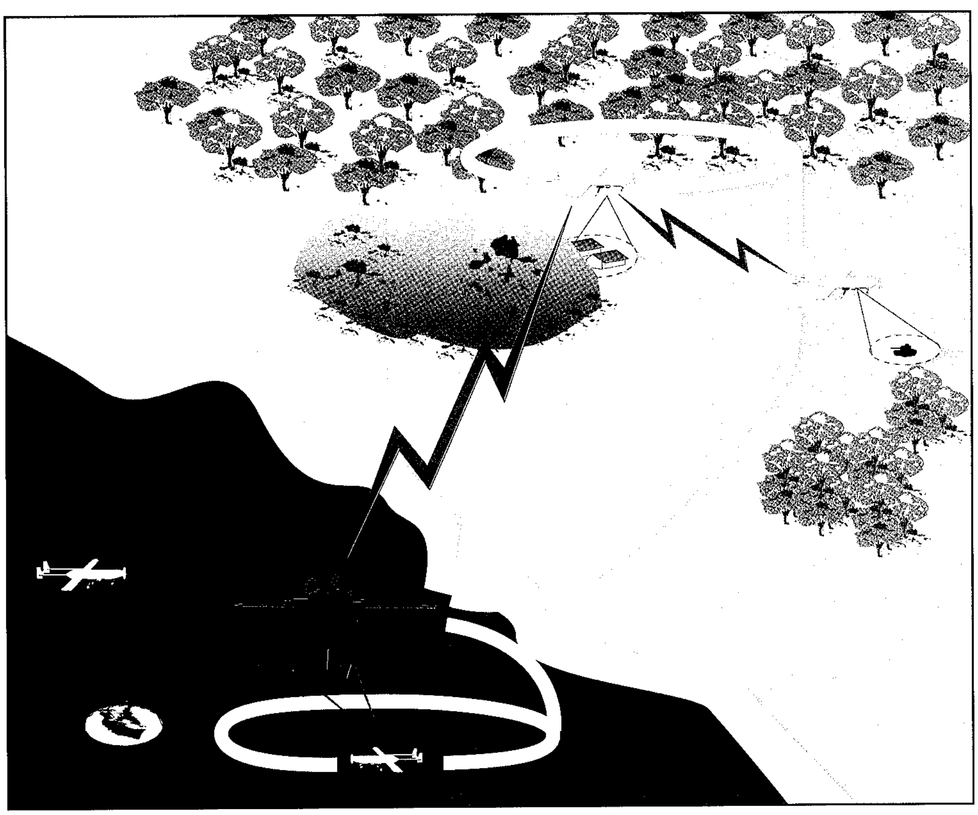


Figure 3-6 Shipboard Variant CONOPS

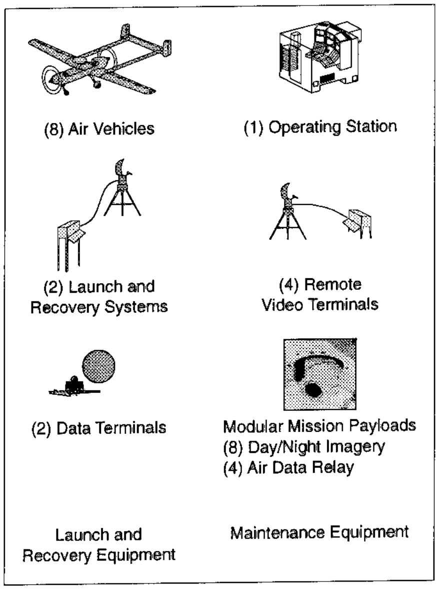


Figure 3-7
Shipboard Variant Description

ernment for TET and LUT.

Both contractors were obligated to develop a block modification plan which included modifications required for their system to meet the full capacity desired by the Government users. The initial contract included not-to-exceed pricing of variable quantity options for three subsequent production buys, interim contractor support for testing and fielding, and depot-level support, training, and technical data (to be procured for the selected system only).

Following TET, LUT I, selection of the "best value" system, and DAB approval, an LRIP contract for the Hunter UAV was awarded in February 1993 to IAI and subsequently novated to TRW. The award covers the production of seven systems which must complete first article test and system qualification testing, formal IOT&E, and the physical configuration audit. Delivery of the first LRIP systems begins in FY94.

Maneuver Variant

The Maneuver Variant acquisition strategy is to optimize experience from the Hunter UAV baseline to ensure maximum C&I and achieve competition where possible. The downsized ground control equipment is being procured sole-source from TRW to ensure commonality in mission planning and system control software as well as system data links. The remaining hardware, including the air vehicle, modular mission payload, and required launch and recovery equipment, together with the integration of requisite GFE, will be procured through a competitive cost plus incentive fee contract to be competed in FY95. The Hunter UAV GCS, required for augmentation of the USA Maneuver Variant, is being procured through a sole-source contract with TRW. A sole-source cost plus incentive fee contract with TRW will be used for integration and testing of the Maneuver Variant air vehicle into the JT UAV System and the development/modification of Hunter UAV training, maintenance, and supportability provisions, thereby ensuring maximum UAV commonality.

3.1.5 Status

Hunter

The LRIP contract for the Hunter UAV was awarded on 12 February 1993. In September 1993, a limited logistics demonstration was completed. During FY93 a total of 420 flight hours consisting of 114 individual contractor and training flights were conducted. Of the total 420 hours, 146.4 flight hours consisted of 12 mission flights performed at the Electronic Proving Ground, Fort Huachuca, AZ using target boards and tactical targets; 13.5 flight hours consisted of 4 mission flights using maritime targets and scenarios; 14.2 flight hours consisted of 5 flight tests using electromagnetic interference, and performing infrared (IR) and radar cross section (RCS) signature measurements; and 128 flight hours consisted of 18 LUT flights using low-intensity and mid-intensity conflict scenarios. Shipboard demonstration flights in December 1993 consisted of 37.1 hours, 28.2 hours of land based and 8.9 hours of shipboard flights. The first production Hunter UAV system of the 50 to be built will be delivered in May 1994, marking a new milestone for the program.

With respect to Hunter training, several variations of training devices are currently being developed for the Hunter UAV. Each system contains an operator proficiency trainer as part of the GCS. This allows for continued proficiency training of the operators via simulation of air vehicle operation. TRW is currently developing a package of training devices to be placed in the institutional training base at Fort Huachuca. These devices will be used to train both operators and maintainers.

Maneuver Variant

In 1992, the Maneuver Variant program completed technical demonstrations of air vehicles and FLIR payloads. The objective of the demonstrations was to reduce risk by demonstrating the maturity of technology for the 200-lb class air vehicle and for FLIRs less than 50 lbs. FLIR demonstrations were successfully completed in January 1992, while the air vehicle demonstrations for the 200-lb class were successfully completed in July 1992. Six contractors took part in the demonstration: Westinghouse, Huntsville, AL; AAI Corporation, Hunt Valley, MD; IAT, Huntsville, AL; General Atomics, San Diego, CA; Daedalus Research, Logan, UT; and McDonnell Dou-

glas, Mesa, AZ. Three contractors participated in the FLIR technical demonstrations: Kollmorgen, North Hampton, MA; Rafael, Haifa, Israel; and Rockwell-Collins, Anaheim, CA.

The demonstrations proved that maneuver-type air vehicles and payloads are capable of performing within the technical parameters required for the Maneuver Variant UAV. The demonstrations provided a forum for identifying potential problems that could affect schedule or technical performance. This problem identification is being used to further minimize risk.

RFPs were released in March 1994 to TRW for downsized and common hardware that is specifically designed for the required mobility of the Maneuver Variant, but also supports the family of UAVs. The final draft of the ORD is in staffing and has been signed by the USA. Final USN approval is deferred until completion of the cost and operational effectiveness analysis (COEA), currently scheduled for July 1994.

Shipboard Variant

In January 1993, the LRIP acquisition decision memorandum re-established the objective of a maritime capability for the Hunter UAV. The Chief of Naval Operations provided a requirement for 18 maritime ships. Pending completion and Service approval of the formal CONOPS, each system is installed as an integral part of the ship's weapons/sensor suite.

In early December 1993, an initial capability demonstration was successfully completed onboard USS Essex (LHD 2). The demonstration included control turnover with a shore-based system, 24 touch and go landings, 4 shipboard launches (both deck run and RATO), 7 arrested landings, and video downlink distribution. The Hunter UAV is considered basically compatible with the amphibious assault ship flight deck. The lessons learned from the demonstration have provided a basis for system/ship interface and configuration analysis through FY94, integration and testing in FY95, and installation of the first system in FY96 for Fleet evaluation and subsequent 1997 IOC.

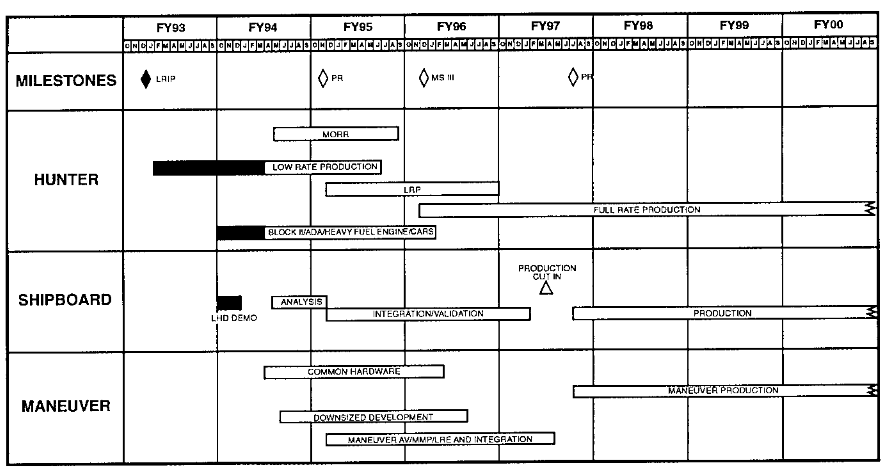
3.1.6 JT UAV Schedule

The master schedule for the JT UAV program is shown in Figure 3-8. The schedule displays information for the Hunter UAV, Shipboard Variant, Maneuver Variant, and upgrades to the system.

3.1.7 Hunter Block II Upgrades

Hunter Block II upgrade options in the existing contract with TRW were exercised subsequent to DAB approval to enter into LRIP. Block II modification kits are planned to be purchased so that all Block 0 baseline systems can be upgraded. The specific improvements comprising Block II are as follows:

Autosearch - The autosearch function will enable the payload to perform an automatic pattern search (step-stair) of a designated area. This Block II software upgrade to the GCS allows area, point, or route searches for optimal target detection by considering sun angle, target types, terrain, threats, and mission-related factors. Autosearch carries out planned searches, up to 25 square kilometers, while controlling the payload, air vehicle flight path, and air vehicle altitude. It enables the operator to insert new data or to replay a search in progress, to generate map displays of the search area with real-time progress, or to display a selected target type silhouette in the scene viewed. It will also have the ability to collect and



LEGEND

ADA = DoD Programming Language
CARS = Common Automated Recovery System
C/304 MI = C Company 304th Military Battalion Intelligence
LHD = Landing Helicopter-Dock
LRIP = Low Rate Initial Production
LRP = Low Rate Production
MORR = Maturation and Operational Risk Reduction
MS = Milestone
PR = Program Review

Figure 3-8 Joint Tactical UAV Program Schedule

store images of interest in automatic or manual search modes.

Autotrack - The autotrack function enables the payload to automatically track operator-selected moving or stationary targets. A video tracker maintains payload line of sight on the desired object without operator action. It also uses "camera guide mode" to steer the air vehicle to keep the target within the field of view and provides limited track through obstruction in "coast mode." The necessary hardware/design changes for autotrack require minor panel additions for the GCS operator; hardware and software changes are principally air vehicle-based.

Heavy Fuel Engine (HFE)

The Hunter ORD requires use of HFEs; however, at the initiation of the Hunter program, technology did not support use of a HFE for the air vehicle. Consequently, a program to acquire a gasoline engine with a pre-planned product improvement (P^3I) to develop a HFE was approved. In concert with that program, the UAV JPO initiated an effort to advance the state of the art in air vehicle HFE technology. In 1993, the UAV JPO technology program demonstrated a 50 horsepower HFE. Meanwhile, with contractor selection, the SR UAV air vehicle requirement matured into a need to provide dual 65 hp HFEs for the Hunter. A search again failed to identify an existing suitable engine; therefore, the P^3I effort was initiated.

The prime contractor, TRW, is conducting this program in three stages: Stage 0 - source analysis, technical qualification, and selection of an HFE developer subcontractor; Stage I - design, development, qualification, and demonstration of the engine by the subcontractor; and Stage II - engine to airframe integration and evaluation testing. In part, Stage II will be conducted in parallel with Stage I. This stage will also include all evaluation testing (including flight testing) necessary to verify that requirements are met.

The Stage 0 contract was awarded in September 1993 and the RFP released to 14 potential vendors the week of 7 March 1994. The risks lie in the fact that a 65 hp class UAV HFE has not been demonstrated, and integration of the engine might require modification to the current air vehicle design because of weight and shape differences.

Common Automatic Recovery System (CARS)

Test experience to date has demonstrated the need for an automatic recovery system to reduce operational mishaps, operator fatigue, operator training requirements and associated costs. The CARS has been demonstrated by the USN MAVUS II Program and upon completion of this program the CARS equipment will be utilized in the JT UAV CARS Program. Additional CARS equipment will also be purchased directly from Sierra Nevada Corporation as GFE to support the JT UAV CARS Program.

The JT UAV CARS Program will be conducted in three Phases as follows: Phase I - Land-based Concept Definition and Flight Demonstration; Phase II - Shipboard Adaptation and Land/Sea Flight Demonstration; and Phase III - Land/Sea Final Integration.

The contract to initiate Phase I was awarded in March 1994. The GFE contract is planned for award in August 1994. The first land-based flight demonstration is planned for the 2nd quarter FY95 and the sea-based flight demonstration is scheduled for the 4th quarter FY95. The final integration phase will be completed during the 2nd quarter of FY96.

3.1.8 Hunter Block III Upgrades

The Hunter UAV program also includes a proposed Block III improvement program that addresses advanced development, prototyping, and testing needed to incorporate additional required sensor payloads; command, control, and communications (C^3) upgrades; survivability improvements; and data link hardening. The improvement program will capitalize on hardware funded and developed by other activities. Improvement program priorities are being established based on user needs and technology availability. Payload and other activities yet to be funded or scheduled include ELINT, signals intelligence (SIGINT), radars, meteorology, survivability, and a lightweight hardened data link.

3.2 FIELDED SYSTEM (INTERIM TACTICAL UAV SYSTEM) PIONEER

3.2.1 Background

Operations in Grenada, Lebanon, and Libya identified a need for an on-call, inexpensive, unmanned, over-the-horizon targeting, reconnaissance, and BDA capability for local commanders. As a result, in July 1985, the Secretary of the Navy directed the expeditious acquisition of RPV systems for fleet operations using nondevelopmental technology. Two Pioneer systems were procured by the Navy for an accelerated testing program in 1986. This effort culminated in installation and deployment of Pioneer onboard the USS Iowa (BB-61) in December of that year. In September 1987, routine deployments of the Pioneer system onboard battleships commenced. During 1987, three systems were delivered to the USMC, and within the next seven months they deployed to Morocco in support of an allied amphibious assault training operation and to the USMC base at Camp Pendleton, CA for Exercise Kernel Blitz. In 1990, a system was delivered to the USA.

Pioneer's operational history includes its unprecedented success during Operations Desert Shield/Desert Storm. USA, USN, and USMC commanders lauded Pioneer's operational effectiveness, as six operational units from three Services flew over 300 missions. Only one air vehicle was shot down while three others were hit by ground fire during combat missions and safely recovered. The documented success of Pioneer in supporting combat operations and providing the battlefield commander critical intelligence information established the utility and importance of UAVs in combat. Pioneer was highly praised as "the single most valuable intelligence collector" (LtGen Boomer, Marine Corps Central Command Element Headquarters (MARCENT)), and "unequivocally outstanding" (I Marine Expeditionary Force G-2). Pioneer "proved that the utility of the unmanned aerial vehicle can be decisive in future battles" (ADM Jeremiah, Chairman JROC). USN assets were extremely successful in target selection, spotting naval gunfire, and damage assessment while the battleship's 16-inch guns destroyed enemy targets and softened defenses along the Kuwaiti coastline. The USMC successfully used Pioneer to direct air strikes and provide near real-time reconnaissance for special operations. The USA had great success with BDA, area searches, route reconnaissance, and target location.

Between 1985 and 1993, Pioneer units logged over 9,400 flight hours. The USN has deployed Pioneer on four battleships and two amphibious LPD ships supporting worldwide operations in Africa, Northern Europe, the North Atlantic, the Western Pacific, Korea, the Mediterranean, and contingency operations in the Persian Gulf. The USMC has integrated Pioneer support with WTIs, Kernel Blitz exercises, and US Customs Service operations supporting drug interdiction missions. The USA has utilized Pioneer in support of exercises at the National Training Center as well as other weapons exercises.

The Hunter UAV replaces Pioneer in the USA, USN, and the USMC. Between FY95 and FY97, USMC and USA Pioneer systems will be transferred to the USN to operate until replaced by the Shipboard Variant system. Figure 3-9 shows the Pioneer in flight.

3.2.2 Purpose

The Pioneer system was acquired rapidly, as an interim system, to fill an immediate need to provide the operational forces with deployable tactical assets. The system provides day and night near real-time RSTA, BDA, artillery fire correction/adjustment of fire, and battlefield management within line of sight of its GCS. The air vehicle's low RCS and infrared signature and its ability to operate by remote control make it particularly useful in high-threat environments where manned aircraft would be vulnerable.

In wartime, the Pioneer system can be deployed by MAGTF, USN battle group commanders, or USA division command-

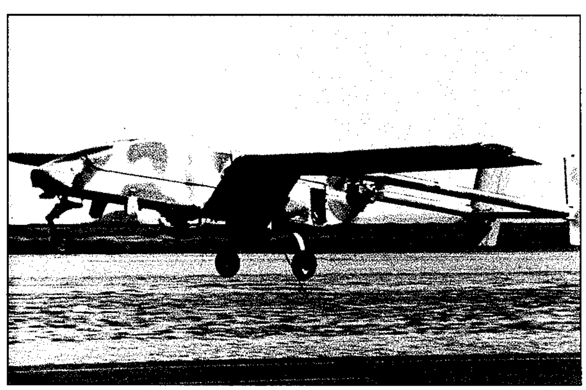


Figure 3-9 Pioneer UAV

ers to provide near real-time tactical information. During peacetime, Pioneer units are tasked with proficiency and mobilization training, tactical intelligence collection, tactics and operational concept development, support and force structure deployment planning, follow-on system and subsystem development, and support of MAGTF, battle group, and divisional training exercises.

System Description

The Pioneer air vehicle is a short-range, remotely piloted, pusher-propeller driven, small fixed-wing aircraft that may be either land-based or ship-based. A Pioneer system consists of:

- Five air vehicles
- One GCS
- One portable control station
- Four IR payloads
- One to four remote receiving stations
- Pneumatic or rocket-assisted launcher
- Net or runway arrestment recovery systems.

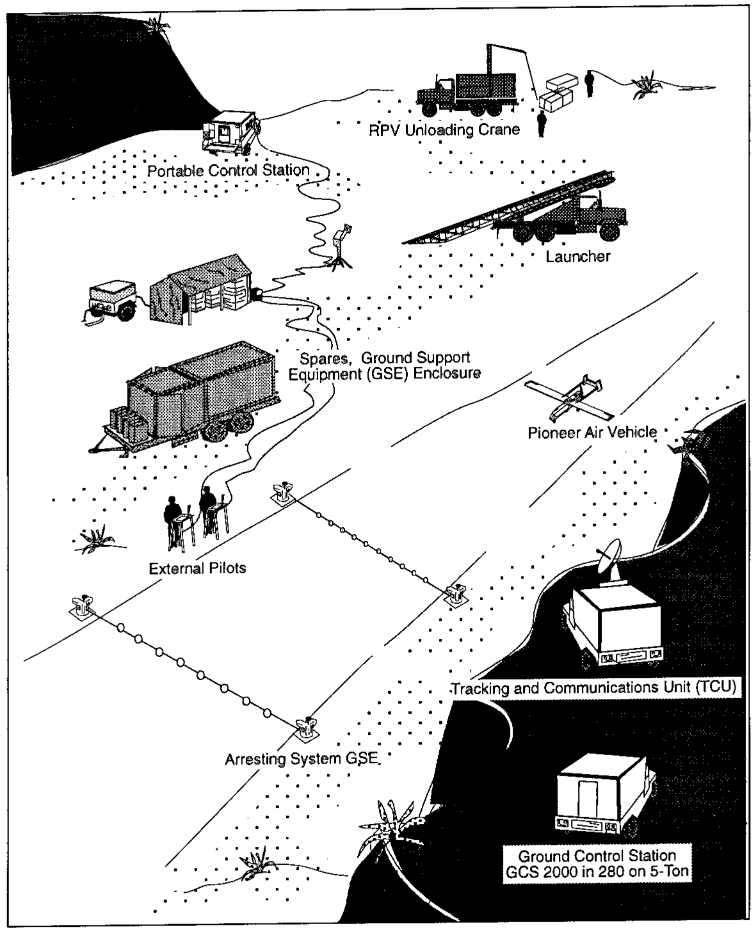


Figure 3-10 Typical Land-Based System

Since decommissioning of the battleships, USN Pioneer systems were installed and deployed on two LPD-4 class amphibious ships during 1993 with plans to install Pioneer on six more ships by 1996. The entire land-based system can be transported with vehicles and trailers. Pioneer is operated remotely from a control station or can be programmed to fly independently. It relays video and/or telemetry information from its reconnaissance systems. Line of sight between Pioneer and a GCS must be maintained at all times for positive flight control and imagery data link. The air vehicle may be handed off from control station to control station, effectively increasing the air vehicle's range to its fuel limit and allowing launch from one site and recovery at another. The Pioneer system can control two air vehicles simultaneously, although the video downlink can be exploited for only one air vehicle at a time. A table of Pioneer system characteristics is found at Appendix B. Figure 3-10 displays the primary components of the Pioneer system.

3.2.3 Acquisition Strategy

The acquisition strategy focused on a baseline approach that provided nondevelopmental equipment to deployed units, test agencies, and tactical development agencies concurrently. Feedback from these groups provided the Pioneer's future operational employment, configuration, and force structure. The Pioneer systems will continue to operate as interim assets supporting deployed and contingency operations until they are replaced by the Hunter UAV. Pioneer systems were initially procured between FY86 and FY88 with final deliveries made in FY90. Additional air vehicles and payloads were procured in FY92 to replace assets lost during Operations Desert Shield/Desert Storm with deliveries completed in early FY94. Procurement of air vehicles, payloads, and particularly, spare

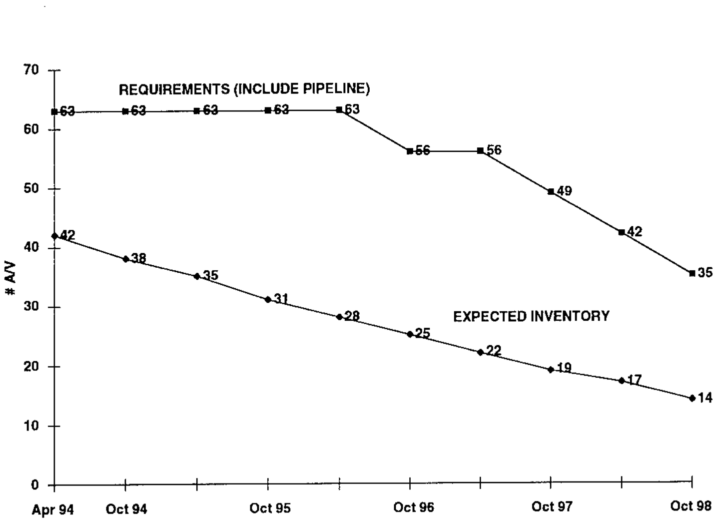


Figure 3-11 Pioneer Inventory Projections

parts is planned through FY98. As shore-based Pioneer systems are replaced by the Hunter UAV, replaced systems will be used as spares in support of deployed USN units until program phase out and termination (presently scheduled for beyond FY99). Exact future Pioneer procurement is unknown now and Figure 3-11 shows requirements against expected inventories given the current number of air vehicles and probable attrition. Pioneer requirements and inventories are also addressed in Section 3.2.4 under planned accomplishments for 1994.

3.2.4 Status

Highlights of Pioneer Accomplishments for 1993

- USMC and USA units supported numerous exercises, including joint operations with the Republic of Korea
- Pioneer equipment installed on two LPD amphibious ships
- Two USN Pioneer detachments deployed aboard LPDs in support of operations in Africa and the Adriatic Sea
- Pioneer FAST at Point Mugu, CA supported test efforts involving mine detection equipment
- Pioneer systems flew over 1250 hours in support of operational deployments and other training exercises.

Pioneer is fully operational and currently fielded with two ship-deployable USN UAV detachments, three USMC UAV companies, and the USA's C Company, 304th Military Intelligence Battalion, 111th MI Brigade, under the Commander, Intelligence Center, Ft. Huachuca, AZ. There are systems at the DUTC at Ft. Huachuca, AZ, the FAST at Pt. Mugu, CA, and a USN shore-based training system at the Naval Air Station, Patuxent River, MD.

Two USN detachments were deployed simultaneously in 1993 to support operations off the coast of Somalia and in the Adriatic Sea. After-action reports from these operations continue to support and validate the operational utility and importance of UAVs in supporting the battle force commanders. USMC and USA units participating in Exercise Team Spirit in the Republic of Korea provided imagery to US forces as well as Korean USMC and USA units. Considerable interest in UAV capabilities was generated among the numerous Korean general officers observing the Pioneer unit operations.

The USA has participated in several combined arms and joint Service exercises. For example, they deployed to White Sands Missile Range, NM to participate in Rapid Strike II and provided imagery support for a simulated rapid deployment, detection, and targeting exercise. Interfaced with other systems, the Pioneer transmitted live video imagery to Fort Belvoir, VA. The Pioneer UAV provided USA civilian and military leadership near real-time video of target acquisition, confirmation, and live tactical missile strikes on two targets, with immediate BDA.

Planned Pioneer Accomplishments for 1994

- Develop and implement a Pioneer Program Combat Readiness model that determines inventory levels and replenishment rates needed to support Service deployments until the Hunter UAV is fielded
- Initiate installation of Pioneer equipment aboard additional LPD-class ships
- Continue to support planned operational deployments as well as training/exercise requirements

- Support test and evaluation of potential UAV payloads

- Exceed operational flight time achieved in 1993.

Pioneer operational/combat readiness to support Service deployments is impacted by attrition of air vehicles as well as repair of repairable parts and procurement of spares. A Pioneer operational readiness model has been developed to measure the quantity and condition of all mission essential equipment assigned to each Pioneer unit and assess the ability of the unit to operate and maintain that equipment. The model compares the overall material and personnel posture of each unit against the minimum requirements for a unit to operate effectively, and provides two measures of Pioneer readiness. The Pioneer Program Combat Readiness indicator is based on the average combat material readiness of the six Pioneer warfighting units. The Program Combat Readiness indicator requires threshold levels of mission-essential equipment, and trained operators and maintainers within a warfighting unit for a non-zero readiness level to be achieved. The Pioneer Program Readiness indicator measures the overall readiness of all Pioneer systems on a linear basis. That is, program readiness does not consider the minimum system requirements needed for combat capability.

The Pioneer Readiness Model has been integrated with the Pioneer reliability, supply, and maintenance data bases to determine inventory levels and replenishment rates required to improve and maintain Pioneer readiness. Figure 3-11 depicts the requirements and expected inventories with no additional procurement. The requirements line reflects the equipment required by each of the fielded units, the reduction of inventory associated with the draw down of the Pioneer system as it is replaced by the Hunter UAV, and the pipeline required to maintain an 85% operational readiness in the operating and training units. The pipeline quantity is calculated based on average annual component attrition, expected component failures derived from historical failure rates, average component repair times, and a 200 flight hour per unit per year operating tempo. The expected inventory is determined by decrementing existing inventory by average annual attrition. The expected inventory line does not account for any future procurements or other readiness initiatives. This level is not adequate to achieve readiness objectives.

To close the gap between projected requirements and depleting assets, a Pioneer Readiness Improvement Program has been initiated. The following major thrusts comprise the program:

- Procure sufficient system components to achieve 85% operational readiness

- Procure sufficient replenishment spares and consumables to maintain 85% operational readiness

- Establish an adequately funded repair of repairables program to minimize requirements for component procurement and the time required to return a component to Pioneer units

- Establish a scheduled depot-level maintenance program for ground components to eliminate flight mishaps caused by catastrophic ground station or ground data link failures

- Invest selectively in safety and reliability improvement, which will reduce cost of ownership of the system. Proposed investment areas for the near term include a more reliable engine, procurement of an alternate band data link, procurement of a global positioning system (GPS) in air vehicles, development of high-altitude, hot day, take-off distance charts, and procurement of a shipboard recovery simulator.

3.2.5 System Interfaces

The Pioneer system has two basic configurations: ship installed and land- based. The ship installation for LPDs is similar to the previous battleship installation in that permanent antennae, fuel storage, and recovery nets are required. The ground control station and other system components are more modular and are integrated/installed within the LPD. Pioneer uses aviation gas, a relatively volatile fuel, requiring special handling and storage procedures. The ship-based Pioneer must be launched with RATO, which requires special storage and handling procedures. Shipboard flight operations require special consideration of air space allocation, control frequency allocation, and electromagnetic interference caused by the launch ship and other accompanying ships. The Pioneer system LPD configuration is shown in Figure 3-12 (see next page). Ship alterations for six LPD class ships and for marinization and cross decking of two Pioneer systems are being planned. Two of the eight LPDs required were modified in 1993. Marinization of two more Pioneer systems is required to be able to maintain a continuously deployed Pioneer capability in both the Atlantic and Pacific Fleets.

The land-based systems are self-contained; however, they do require special facilities to operate. The air vehicle needs a prepared landing surface or runway to set up the arresting gear. There must be sufficient area cleared for the various ground support equipment. Safe aviation gas and RATO storage and handling facilities need to be in place. The vehicles to transport the Pioneer system require service and maintenance facilities.

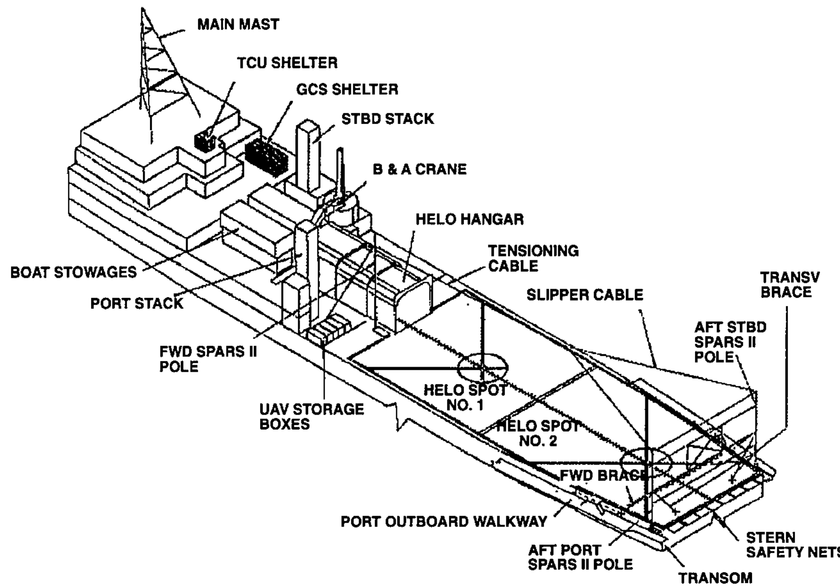


Figure 3-12 Pioneer LPD Configuration

3.2.6 Schedule

The currently fielded Pioneer RPV capability is to be maintained "at an acceptable readiness level" until the Services reach full operational capability with the Hunter UAV as mandated by Congress or assets are depleted due to attrition. All USA and USMC systems will be transferred to the USN between FY95 and FY97 and all USN Pioneer systems and support will be phased out with introduction of the follow-on system. The plan calls for withdrawing the USA Pioneer system at the beginning of FY95, one USMC system during the latter half of FY96, two other USMC systems in FY97 and the system at DUTC in mid FY98. Spares procurement is currently planned through FY98 and outyear material support will be provided by Operations and Maintenance, Navy funded component repair and through the use of withdrawn system assets as spares. Figure 3-13 shows the phaseout schedule for Pioneer UAV units.

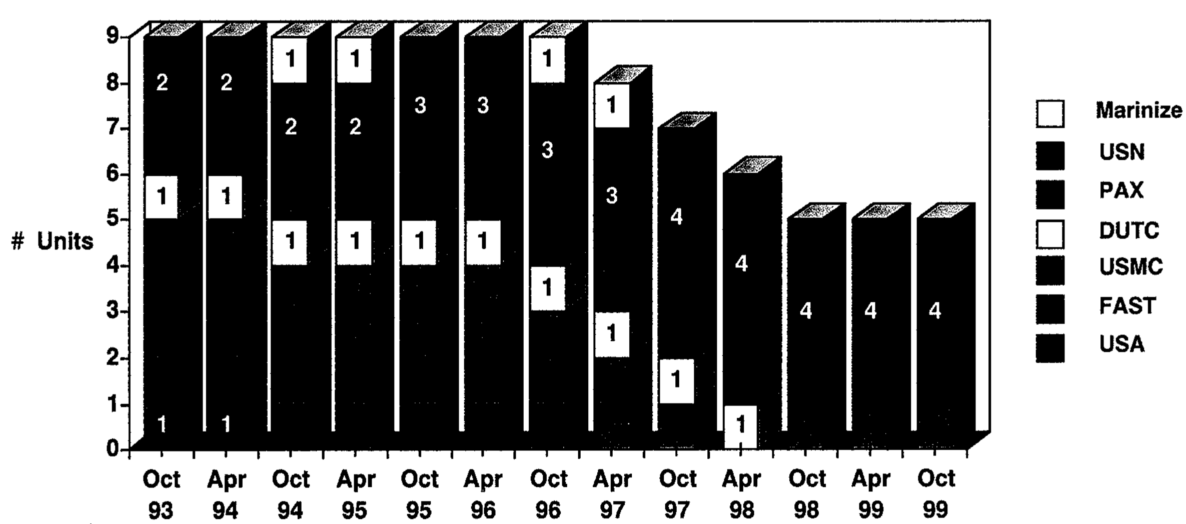


Figure 3-13 Pioneer Phaseout Schedule

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3.3 DEMONSTRATIONS

This subsection describes UAV demonstrations. Demonstrations serve varied but specific purposes related to UAV technology exploitation, requirements, and the user community:

- ACTDs (Sections 3.3.1 - 3.3.2) are a streamlined method for working closely with the user to rapidly demonstrate and field a new capability in limited quantity (in this case satisfying endurance UAV requirements)
- Very low cost UAV operational assessments (Sections 3.3.3 - 3.3.4) are an inexpensive way for user communities to become familiar with UAV operations and to explore employment concepts. In their own right, very low cost UAVs may have roles as "throw away," or expendable UAVs, in satisfying interim capability needs
- VTOL UAV operational assessments and technology demonstrations (Sections 3.3.5 - 3.3.8) provide a means to evaluate VTOL air vehicle candidates (that would become part of the JT UAV System) for small ship platform applications (albeit there presently is no active USN requirement for such a capability), special operations or wherever else vehicle launch and recovery space is nonexistent or at a premium
- Unmanned ground vehicles (UGVs) and related robotics applications (Sections 3.3.9 - 3.3.10) provide an opportunity to share UAV technology with our UGV counterparts, develop common unmanned system requirements, explore joint UAV/UGV CONOPS, and exploit C&I between unmanned air and ground systems.

3.3.1 Medium Altitude Endurance (MAE)

Background

The MAE UAV is a 30-month effort responding to a Joint Chiefs of Staff initiative to bring near real-time imagery to the Joint Task Force (JTF) Commander. The MAE UAV provides the JTF commanders an expendable, long-dwell, narrow area search, tactical UAV system with continuous, near all-weather surveillance and target acquisition over defended foreign areas. Through a reusable/multisensor air vehicle, the system supports RSTA missions as directed by the JTF Commander.

System Description

The system will remain on station at extended ranges (500 nm) for periods exceeding 24 hours using high-resolution sensors to identify and track small, mobile targets (e.g., artillery). The MAE is compatible with, and is cued from, other reconnaissance systems. The imagery is a releasable product to enhance joint and coalition warfighting coordination. As an ACTD, the project development, testing, and demonstration is user dependent. A CONOPS is being developed by a working group with US Atlantic Command lead and membership from Southern Command, the Joint Staff, the UAV JPO, and the TRADOCs from each of the services. The CONOPS guides the testing and exercise of the system so that when deployed, the user will have an understanding of the capabilities/limitations of the system and how to properly task and employ the system. The MAE system will deploy with a "turnkey" operational and maintenance support team. The system will be compatible with existing JTF Commander's (ashore and afloat) command, control, communication, computers and intelligence (C^4I) architectures for data dissemination. Sensor and communications capabilities of the system are:

- EO/IR sensors with ground sampled distance of 16-30 inches
- SAR radar with (classified) intra-pulse resolution
- Satellite communications (SATCOM) datalinks capable of ultra high frequency (UHF) and/or Ku wideband communications
- Trojan Spirit II and joint deployable intelligence support system for imagery dissemination.

A table of MAE system characteristics is in Appendix B. These requirements are delineated in USD(A) memorandum of 12 July 1993 and DUSD(AT) memorandum of 17 November 1993.

Plans for Calendar Year 1994

Source selection for the MAE UAV system was completed in January 1994. The Predator, variant of the General Atomics GNAT 750, was selected. See Figure 3-14 on the next page. UNISYS, Salt Lake City, UT was selected as the datalink contractor. A competitive contract for the SAR was awarded to Westinghouse, Baltimore, MD in March 1994. Early and mid-1994 activities focus on ground/lab test of the EO/IR and UHF satellite com-

munications. By fall 1994, three air vehicles and one GCS will be delivered and flight demonstrations will begin. Field deployment of the EO/IR and UHF communications will begin in January 1995. Ground testing of the SAR and wideband satellite communications link will be conducted by mid-1995.

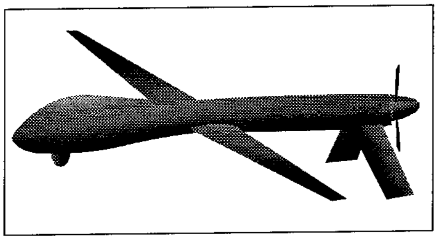


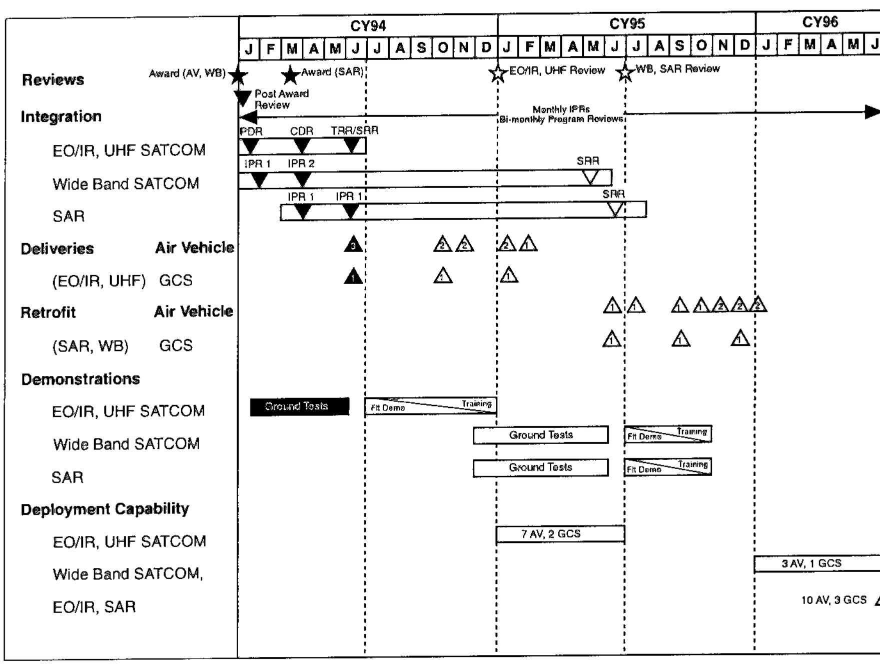
Figure 3-14
General Atomics Predator

By January 1996, three air vehicles and one GCS with full capability will be ready for field deployment (see Figure 3-15).

Interface Relationships

The following briefly describes the interface relationships that the MAE UAV system will have with external systems and identifies possible users of information up to and including national levels. The MAE UAV provides a rapid-response capability to the user. These interface relationships will be used in developing a CONOPS document detailing the purpose, system description, mission, tasking, control, and airspace management for the system.

Operating at medium altitudes up to 15,000 ft MSL, the MAE UAV will possess the capability to disseminate releasable, high-resolution imagery (visible, IR, and SAR) to the Joint Force Commander (JFC), Joint Intelligence Center, or Joint Analysis Center, and the National Military Joint Intelligence Center simultaneously. Thus the MAE UAV makes a significant contribution to the warfighting capability of operational forces. It greatly improves the quality and timeliness of battlefield information while reducing the risk of capture or loss of troops and allows more rapid and better informed decision making from the JFC. The MAE UAV provides long-dwell surveillance capabilities that are particularly valuable when cued by existing national, theater, and tactical collection systems. It can readily perform a multitude



LEGEND

AV = Air Vehicle
CDR = Critical Design Review
EO/IR = Electro-Optical/Infrared
GCS = Ground Control Station
IPR = In Process Review
PDR = Preliminary Design Review
SAR = Synthetic Aperture Radar
SATCOM = Satellite Communications
SRR = System Readiness Review
TRR = Test Readiness Review
UHF = Ultra-High Frequency
WB = Wide Band

Figure 3-15 MAE UAV ACTD Schedule

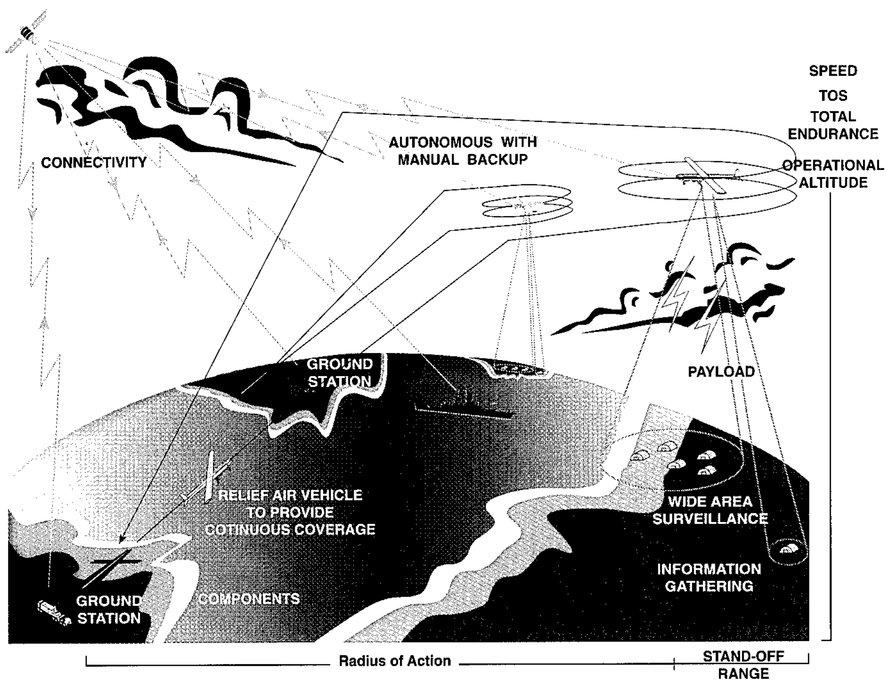


Figure 3-16 HAE CONOPS

of inherently hazardous missions for extended periods of time.

Summary

Allotting these dangerous and/or tedious missions to the MAE UAV increases survivability and frees aircrews for missions requiring the flexibility of a manned system. The MAE UAV is a complementary adjunct to existing communications systems such as Trojan Spirit II and helps to reduce the effect force downsizing will have on operations. The imagery products from MAE UAV include freeze-frame and video clips via the Joint Worldwide Intelligence Communications System. Verbal reports and full video tapes can be provided by an analysis center using MAE data. Inherent in this connectivity is the utilization of Trojan Spirit II, which provides C, X, Ku, UHF, and very high frequency (VHF) communications. If other commands in the C^4I network have the ability to receive those frequencies plus the correct modems to decode the common datalink (CDL) 1.5 megabits per second data stream, the imagery can be directly processed by their respective internal systems.

3.3.2 High Altitude Endurance (HAE)

Background

The requirements for a high altitude, long endurance UAV have been recognized since 1960. Various programs were funded to evaluate and test related technologies. The US Air Force (USAF) prepared an initial MNS in 1990 which was approved by the JROC. This requirement was reiterated in 1992 by the Advanced Airborne Intelligence Collection Systems Study and the Airborne Reconnaissance Requirements Assessment, and again in 1993 by the DoD Deep Target Surveillance Reconnaissance Study. In 1993 the decision was made to follow a multiphased or multitiered approach to the development of endurance UAVs. The initial effort is a US Government program to field a quick-response endurance UAV capable of providing optical imagery in crisis situations. The MAE UAV, an ACTD, is being developed by the UAV JPO as a medium altitude, narrow area search UAV which will possess a more capable payload and a real-time data link capability to a ground station. The HAE UAV is being developed using an innovative acquisition strategy with strict design-to-cost goals.

Purpose

The HAE UAV System is to be an ACTD type of development which will provide a broad area search capability and high quality imagery from SAR and/or EO/IR. It will operate at high altitude (>50k ft) and possess an operating radius of 1,000 miles or greater and an endurance in excess of 24 hours. It is intended to be used by a JTF Commander in support of tactical operations. Figure 3-16 shows the HAE CONOPS. An acquisition strategy for the HAE is being developed.

3.3.3 Pointer Hand Launched UAV

Background

Since 1990 the UAV JPO has been using the AeroVironment Inc., Simi Valley, CA Pointer Hand Launched UAV system to support demonstrations, evaluations, and requirements development. The Pointer is a relatively low-cost UAV that provides the maneuver battalion commander or other user an "eye in the sky."

Operating at 200 to 500 feet above ground level and out to ranges of 3 miles, the air vehicle's TV camera provides real-time, high-resolution color or black and white video imagery for seeing over hills, into urban areas, and around the next bend. Many different reconnaissance and surveillance missions can be performed quickly and effectively, leaving the operator safe from enemy eyes and thus out of harm's way.

Figure 3-17
Pointer Hand Launched UAV

The 8.5-lb composite air vehicle, (see Figure 3-17) which is easily assembled from six parts (interchangeable with other air vehicles), is battery powered, resulting in extremely low noise signature and a short logistics tail. Its small size, 9-ft wingspan and 6-ft length, makes visual detection difficult while contributing to the overall stealthiness of the system. With the small and easily configured ground control station, the entire system can be operationally ready in less than five minutes. At the end of a Pointer mission (up to one hour duration), recovery is executed by an automatic deep-stall maneuver to a soft landing. By simply replacing the air vehicle batteries, the three-person crew can be flying another mission in less than two minutes. Since 1990 Aero-Vironment's Pointer has been the only available system at the very low end of the UAV spectrum. A table of the Pointer system characteristics is in Appendix B.

1993 Accomplishments

In 1993 demonstrations of the Pointer to a variety of potential users and decision makers continued at an accelerated pace. Concurrently, successful deployment to four exercises at the NTC with units of the 1st Cavalry Division, III Corps led to a statement of need by the Commanding General USA III Corps on 15 June 1993 for 30 systems. The remainder of 1994 will be focused on executing a plan to procure, field, and support a USA-validated requirement for these systems for III Corps.

Demonstrations and evaluations of Hand Launched UAVs continue with other users in and outside of the DoD. Activities completed in 1993 supporting demonstrations, program, and technology developments included:

- Completion of a Phase I CEP with the USA III Armored Mobile Corps. ONS of requirement for 30 Hand Launched UAV systems submitted on 15 June 1993
- Successful demonstration in March 1993 at the Advanced Warfighting Demonstration of Battlefield Synchronization, USA Armor Center, Mounted Warfighting Battlespace Lab (MWBL), resulting in a recommendation to field a Hand Launched UAV system
- Deployment to the JRTC, Ft. Polk, LA with the 82nd Airborne Division, in support of the USA Infantry Center, Dismounted Warfighting Battlespace Lab (DWBL), for new technology evaluation in Operations Other Than War
- Initiation of the Phase II CEP conducted by the USA MWBL
- Successful deployment with the Oregon National Guard in operational counterdrug and other law enforcement missions completing Phase I of the NGB/Drug Enforcement Agency (DEA) evaluation
- Three successful test flights of GPS and autonavigation on the Pointer system
- Development of a personal computer-based pilot's training simulator for the Pointer Hand Launched UAV. Deployed to support training at Ft. Hood, TX 3-14 January 1994
- Deployment to the USA Corps of Engineers Construction Engineering Research Laboratory (USACERL) for use in environmental assessment and cultural resource management, including the initiation of development of multispectral infrared payloads
- Successful technical experiments on the interoperability of the Pointer Hand Launched UAV with the Surrogate Teleoperated Vehicle (STV) UGV at Redstone Arsenal, AL, conducted jointly between the UGV JPO and the UAV JPO, supported by the Defense Evaluation Support Activity (DESA)
- Numerous demonstrations, including those to the DUSD(AT), Bureau of Land Management, National Park Service, US Forest Service, and the Federal Bureau of Investigation (FBI).

1994 Plans

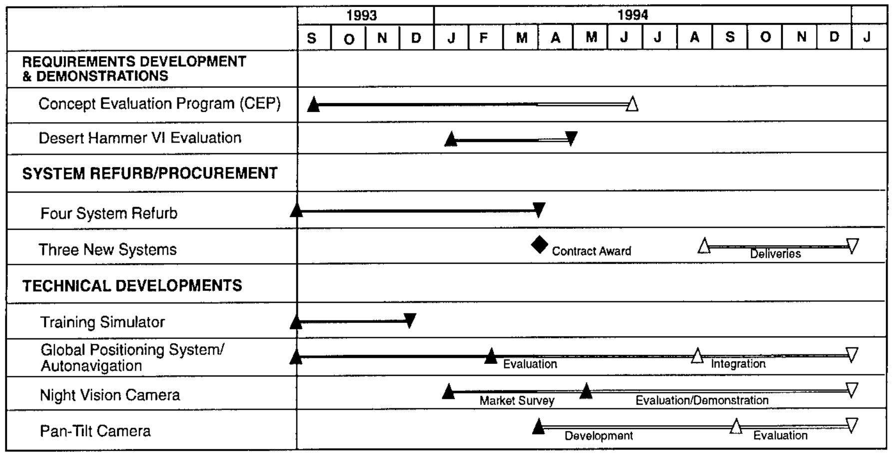


Figure 3-18 Pointer Hand Launched UAV Schedule

The focus of activities in 1994 concentrates on supporting the evaluation of the Hand Launched UAV concept by the USA TRADOC, Armor Center, MWBL. The TRADOC CEP will support development, validation, and approval of a Hand Launched UAV requirement. Four existing Pointer systems have been refurbished and upgraded for III Corps commanders for CEP exercises at Ft. Hood, TX and the NTC. TRADOC evaluators from Ft. Knox and Ft. Huachuca make up the independent evaluation team. Pointer training of 10 soldiers (3 Hand Launched UAV teams) of the 1st Brigade, 1st Cavalry Division was completed on 14 January 1994. These soldiers will operate the Pointer Hand Launched UAV throughout the evaluation.

As a follow up to the successful battlefield synchronization demonstration in March 1993, the UAV JPO supported the USA Armor Center in demonstration of the Hand Launched UAV at the NTC, Exercise Desert Hammer VI, in April 1994 with the Task Force 1-70. This is part of an exercise commissioned by the Chief of Staff of the Army to demonstrate the future of land mobile combat, winning the battlefield information war through digitization and synchronization.

Other tentative plans with the USA include follow up support to the USA Infantry Center, DWBL, for Hand Launched UAV evaluation in Operations Other Than War in August 1994. This provides an opportunity for early user evaluation of the GPS/autonavigation-equipped system. The NGB is planning to use Hand Launched UAVs to continue its ongoing evaluation of UAVs to support law enforcement, counterdrug, and border patrol missions to name a few. This evaluation will result in a statement of need for these systems.

All the foregoing activities in support of operational users are directed toward the fielding of an affordable, supportable, effective Hand Launched UAV for III Corps and other USA requirements. Several activities scheduled for 1994 that will help the UAV JPO achieve the goal of responsive support to our users of Hand Launched UAVs include:

- Procuring three additional Hand Launched UAV demonstration/ evaluation systems
- Completing Hand Launched UAV frequency study for a military frequency allocation
- Conducting a Hand Launched UAV User's Conference for DoD and non-DoD customers to address user needs and demonstrate new and projected technology developments.

The schedule (see Figure 3-18) shows the activities planned for 1994. Funding for the use of Pointer, i.e., training, technical, and logistics support for these evaluations, is provided by the customer.

Technology Enhancements

The basic Pointer configuration has served the Hand Launched UAV user well over the past four years; however, goals for enhancements such as improved navigational capability and night imagery have been identified. In response to a DEA funded requirement for GPS/ autonavigation and pan/tilt camera, the UAV JPO awarded a contract to AeroVironment to develop these capabilities for Pointer. GPS/autonavigation has now been developed and integrated with the basic system. A full-function flight test was conducted in February 1994, demonstrating operation of the GPS with heading hold, waypoint navigation, auto loiter, altitude hold, and return home features.

GPS/autonavigation components enhanced graphics on the personal computer (PC)-based system provide user-friendly graphical displays of air vehicle location, heading, and positional and attitudinal telemetry. The lightweight pan and tilt camera will complete this enhancement effort in 1994. Four air vehicles and two ground control units equipped with these capabilities will be delivered to the UAV JPO for early user evaluation.

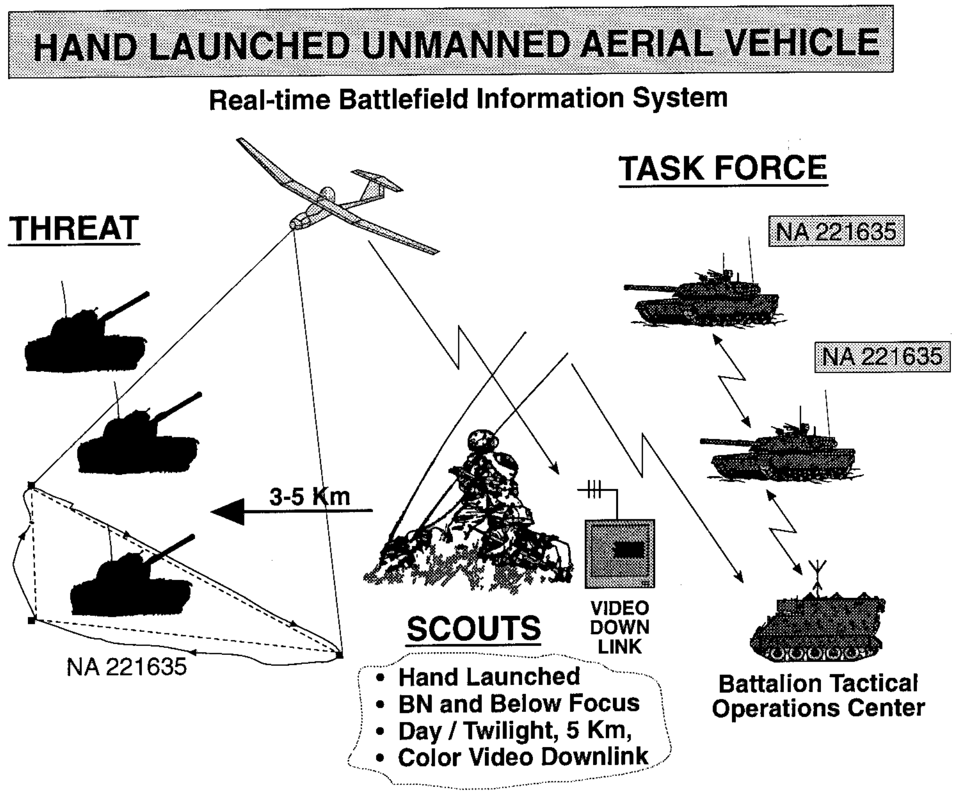


Figure 3-19 Real-Time Battlefield Information System

Figure 3-19 shows a real-time battlefield information system using GPS waypoint navigation.

The COTS strategy for enhancements to the Hand Launched UAV system is driven by the need to use commercially available, reliable, lightweight components and subcomponents that require integration into the small and light air frame.

Dual-Use and Defense Conversion Opportunities

There were many exciting developments in the application of Hand Launched UAVs to nonmilitary uses in 1993. The attractiveness of these systems to nonmilitary users is often the same as for military users, e.g., low cost, rapid response time, and minimal crew and logistics burden with high reliability and effectiveness. In keeping with DoD initiatives to promote dual-use technologies and defense conversion, the UAV JPO conducted Pointer demonstrations for a variety of potential users, including the Bureau of Land Management, National Park Service, and US Forest Service. A Pointer demonstration in December at prehistoric Anasazi native American ruins near Español, NM was attended by nearly 20 persons representing the above-mentioned activities interested in applications ranging from law enforcement and surveillance support to scientific research.

A full range of cultural and natural resource management tasks is possible with such systems. Also in 1993, the USACERL began a one-year study and development effort to consider environmental surveillance applications and to develop special multispectral infrared payloads for the assessment and management of military training areas, agricultural, and natural resources. The UAV JPO has recently been working with members of the FBI to promote transfer of this technology to local and state law enforcement agencies.

The highlight of 1993 in non-DoD uses of the Pointer Hand Launched UAV was a full year of operations with the Oregon National Guard in support of local law enforcement agencies primarily in support of counter drug surveillance and preraid activities. In one instance, Pointer, undetected by suspects under surveillance, provided real-time video intelligence of a drug dealer's compound, which allowed an effective and rapid arrest of the suspects and confiscation of contraband. There were no injuries to any of the

officers or suspects involved in the raid. These missions, 12 in all, were generally conducted over hilly, wooded terrain and in several instances in challenging weather conditions. In all cases they were conducted in civilian air space with the knowledge and cooperation of the Federal Aviation Administration (FAA).

The UAV JPO continues to identify and support demonstrations and evaluations of the Hand Launched UAV concept to nonmilitary customers consistent with military priorities and system availability.

3.3.4 EXDRONE UAV

Background

The EXDRONE program began as a research and development effort to develop a low-cost expendable drone to carry a VHF communications jammer. The baseline air vehicle was initially developed by the Johns Hopkins University Applied Physics Laboratory, Laurel, MD in the early 1980s. BAI Aerosystems, Easton, MD is now the prime contractor for the program. The program strategy is to integrate COTS and government off the shelf components and payloads as technology developments and funding permit. In November 1991, BAI Aerosystems of Easton, MD was awarded a contract for the production of 100 air vehicles. From April 1992 to October 1993, these air vehicles were used to demonstrate a low-cost, expendable, reconnaissance UAV capability.

In response to user inputs, the air vehicle was modified and improved to include down-looking payloads, pneumatic rail launch, and a GPS-based autopilot. In July 1993, CG MCCDC established a requirement for four improved EXDRONE systems. In December 1993, a contract option was exercised for the production of an additional 60 air vehicles.

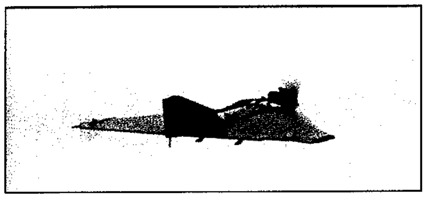


Figure 3-20
EXDRONE In Flight

EXDRONE is being procured for use as a low-cost reconnaissance air vehicle equipped with a down-looking color TV camera with zoom lens and pan and tilt capability. Developmental testing for the latest system upgrades is complete. The first two systems are being fielded with the 1st UAV Company, Twentynine Palms, CA and the 1st Cavalry Division, Ft. Hood, TX in June 1994. Training in support of fielding these two systems began in April 1994.

Figure 3-20 shows the EXDRONE in flight and Figure 3-21 shows the EXDRONE during rail launch.

System Description

The EXDRONE is a delta platform flying wing. The power plant is the reputable Quadra 100SS aero engine designed for use in scale models. The flight control system consists of an uplink receiver connected to a GPS-based autopilot. The air vehicle is gyro stabilized and capable of preprogrammed autonomous flight. The EXDRONE has a launch weight of 89 lbs and a 25 lb payload capacity. It is launched by pneumatic rail and recovered by parachute. The air vehicle has a service ceiling of 10,000 ft with a mission altitude of 3,000 - 4,000 ft above ground level. It has a top speed of 100 miles per hour, a mission endurance of 2.5 hours, and an operational range of 50+ kilometers (line of sight). The GCS is capable of controlling two air vehicles simultaneously.

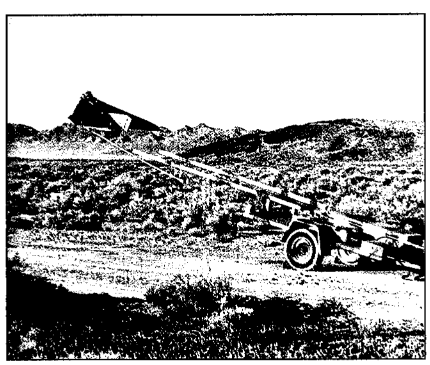


Figure 3-21
EXDRONE Rail Launch

An EXDRONE system consists of 10 air vehicles, 2 GCSs and ground support equipment that includes a pneumatic launcher. The system is transported in the field by two high mobility multipurpose wheeled vehicles and into theater by one C-130. The GCS interfaces with any equipment that has a standard RS-170 connector and has been successfully integrated with the USMC Intelligence Analysis System. A table of EXDRONE system characteristics is in Appendix B.

Concept of Operations

The EXDRONE system is best employed when cued by another intelligence system or target location system. The operational scenario proceeds with a pneumatic rail launch from the regimental or brigade tactical operation center/combat operation center area. The air vehicle climbs to operational altitude and dashes to the objective area. The air vehicle is controlled by the launch team if the objective is within 50 kilometers. To extend operational range, a forward control team equipped with a GCS can be positioned closer to the objective area. The air vehicle will loiter in the objective area for up to 2 hours. If additional coverage

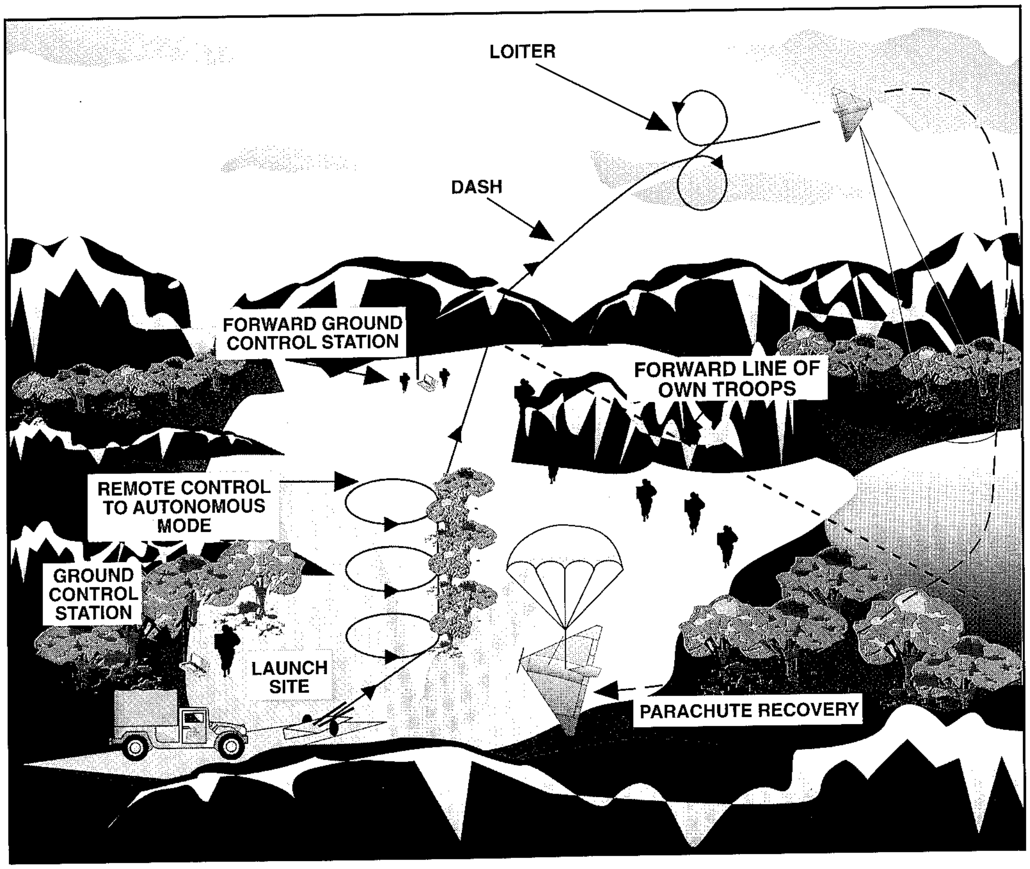


Figure 3-22 EXDRONE Operational Scenario

of the target area is needed, another air vehicle is launched prior to return of the first air vehicle. The air vehicle is flown autonomously to the recovery area and recovered by parachute. (See Figure 3-22).

Field Demonstrations

During recent field demonstrations, USMC and USA units used the system in seven major exercises. User input has guided system upgrades and improvements. Each unit has developed similar UAV command and control, airspace coordination, system cueing, air tasking, and unit standard operating procedures. The demonstrations have also assisted in refining and validating Maneuver Variant UAV requirements. Personnel from the 101st Airborne, 1st Cavalry, 24th Infantry, and 2nd Marine Divisions participated in field demonstrations. The 101st Airborne and 1st Cavalry Divisions continue to operate the system.

FY 1993 Accomplishments

Based on user input and experience the following upgrades were made:

Pneumatic launcher: Five pneumatic launchers were competitively procured from Continental RPV of Barstow, CA. The pneumatic launchers are now used exclusively for launching the air vehicle and have improved the launch success rate to over 95%.

Recovery parachute: Prior to the recovery parachute, units were taught to land the air vehicle with "stick and rudder." This procedure caused an unacceptable attrition rate. Since the introduction of parachute recovery, attrition has been cut dramatically. The parachute is a COTS "man-rated" reserve chute.

Low light payloads: Image intensifying and FLIR payloads were integrated and flown during testing at Dugway Proving Ground, Tooele, UT in April 1993. The EXDRONE incorporates night payloads as they become smaller and less expensive.

Improved power plant: The Quadra 100SS was tested and approved for use in

future air vehicle buys. This engine is more reliable while providing more power with less vibration and noise at a lower cost than the old engine.

FY 1994 Plans

Procure 60 air vehicles: In December 1993 an option was exercised to procure 60 additional air vehicles. These air vehicles will be used to build four systems for USMC and USA evaluation and use. Systems 1 and 2 are to be fielded in June 1994, and systems 3 and 4 will be fielded early in FY95.

Down-look zoom payload: This payload consists of the COTS Pulinex TM-7i color camera that provides 570 lines of resolution and a 6X zoom lens. The payload was tested at the Dugway Proving Ground in March 1994 with results indicating a national imagery interpretability rating scale rating of 4 at 3000-4000 ft above ground level.

Shift uplink to UHF band: The upgrade most requested by users was the ability to shift the uplink frequency out of the VHF band. The VHF band is used for tactical communications. If proper frequency coordination was not accomplished, the EXDRONE system was subject to "friendly" jamming. The UHF uplink was tested at Dugway in March 1994 with an operational range in excess of 50 kilometers.

Integrate COTS pan/tilt/zoom payload: The second most requested upgrade is an ability to "steer" a payload and spotlight a target. Several COTS payloads will be evaluated and the systems' microprocessors will be upgraded from 16 bit to 32 bit capability. Testing will begin in June 1994. Systems 1 and 2 will receive the payload in November 1994, and systems 3 and 4 will be delivered with the payload.

Integrate tactical remote sensor system (TRSS) airborne relay: The TRSS airborne relay is a GOTS payload that is intended to be carried by the AV-8B Harrier. Development costs forced a reevaluation. Pending approval, the EXDRONE will integrate the TRSS system beginning in the 3rd quarter of FY94.

Monitor night payload development: Image intensifier and FLIR technology is getting smaller and cheaper. A market survey will be completed in the 4th quarter of FY 94 to determine if it is economically feasible to field EXDRONE systems with integral night payloads. If it proves practical, COTS payloads will be integrated and demonstrated in FY95.

Summary

Demonstrations of the EXDRONE system have been successful, with units logging over 300 flights and approximately 500 flight hours while participating in 7 major exercises. The EXDRONE has successfully followed convoys, conducted route and point reconnaissance, and observed artillery fire. The air vehicle has proven to be a very stable platform for small (25 lbs) payloads. The EXDRONE is an effective, low cost UAV system responsive to the user and his requirements. As the Assistant Division Commander of the 101st Airborne Division wrote on 8 March 1994, "The 101st Airborne Division (Air Assault) considers the BQM-147A EXDRONE an important component of its intelligence system and is committed to fielding a UAV for the division. If we were to deploy to war today, the EXDRONE would go with us."

3.3.5 Maritime VTOL UAV System (MAVUS) II Program

Background

In 1990, a project agreement was signed between the Canadian and US Governments for a cost-sharing technical demonstration of a MAVUS. MAVUS I was the first phase of the program, which culminated in an at-sea operational and technical demonstration onboard a USN FFG-7 frigate class ship. The US and Canadian Governments share contract costs for the second phase (MAVUS II) which was awarded 28 May 1993. A table of VTOL UAV operational requirements is in Appendix B.

Purpose

The MAVUS II program is intended to conduct additional technical demonstrations, including automated landing on a USN combatant and continued shipboard operations and tactics development. The MAVUS II program will reduce technical risks associated with employing UAV systems onboard USN combatants.

System Description

The MAVUS II system consists of the following:

- Two air vehicles
- Four payloads
- Mission planning and control station (MPCS)
- Transverser
- Landing grid

- Two datalink antennas
- Automated landing system
- Manual landing system
- Portable computer and control system
- Data acquisition station
- Refueling station
- Support equipment.

Concept of Operations

The MAVUS II program assists in weapon system mission planning, provides for collection of intelligence, and supports the command, control, and communications functions of a USN combatant using minimum manpower. The system conducts reconnaissance and surveillance with EO and IR sensors and provides over-the-horizon detection, classification and localization, and BDA of land and sea targets. In addition, the MAVUS II system employs a communications relay to further demonstrate the potential operational capabilities of maritime VTOL UAVs. A table of MAVUS II operational capabilities is in Appendix B. The MAVUS II air vehicle is shown in Figure 3-23.

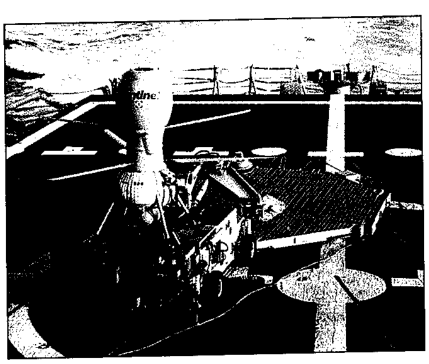
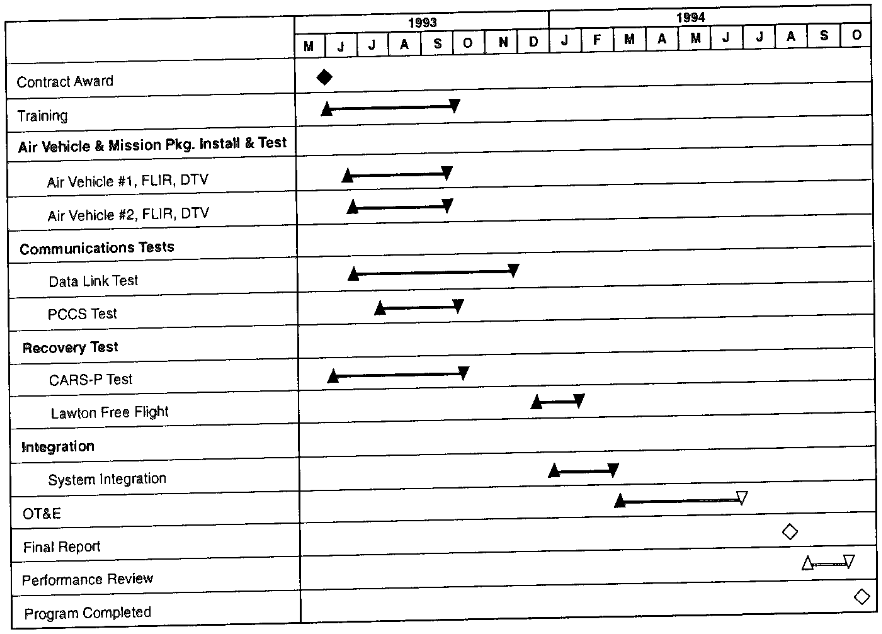


Figure 3-23
MAVUS II Air Vehicle



LEGEND
CARS-P = Common Automatic Recovery System Prototype
DTV = Daylight Television
FLIR = Forward Looking Infrared
OT&E = Operational Test and Evaluation
PCCS = Portable Computer and Control System

Figure 3-24 MAVUS II Technical Demonstration Schedule

The MAVUS II program is evaluating the flying qualities, performance, and dynamic interface of VTOL UAVs along with reduction of technical risks associated with using VTOL UAVs onboard USN combatants. Two major elements of MAVUS II are to demonstrate:

- The automated takeoff and landing system. Safe and reliable VTOL operations on small ships require automated takeoff and recovery in all types of weather. An at-sea operational demonstration of CARS with the Canadair CL-227 Sentinel system will be conducted during FY94
- Air vehicle technologies. The MAVUS II effort will evaluate the ability of UAV coaxial helicopter air vehicle technology to operate in a USN surface combatant environment.

Status

The MAVUS II UAV System was assembled at the Canadair facility in Montreal, Canada. Laboratory integration and tether flight testing were completed in December 1993. A common automatic recovery system prototype (CARS-P) was integrated into the system and flight tested at the Canadair Flight Test site in Lawton, OK between 22 December 1993 and 31 January 1994. During the test flights, 26 automatic ap-

proaches were made with 9 successful automatic recoveries. Recoveries were initiated from the outer boundaries of the recovery initiation box. Touchdown points for the automatic recoveries ranged from 1.56 to 11.7 inches from the center of the grid.

The MAVUS II system was installed on the USS Vandegrift (FFG-48) in San Diego, CA in February 1994. The system will become an integral part of the ship combat system and will be operated and evaluated by the ship's crew throughout the scheduled demonstration period (March through May 1994). Representatives from COMOPTEVFOR will be onboard to continue the early operational assessment initiated during the MAVUS program.

Schedule

The MAVUS II demonstration is to be completed by the end of June 1994, and the resultant data developed and lessons learned during the effort will be incorporated into the Shipboard Variant program. The projected technical demonstration schedule for MAVUS II is contained in Figure 3-24 (see previous page).

3.3.6 UAV Ship Combat System Integration (SCSI) Demonstration Program

Background

A 10 December 1991 DAB authorized use of FY92 congressionally added funds for a technology demonstration program to reduce technical risks associated with employing UAV systems onboard USN ships. The technology demonstration elements included air vehicles, automated recovery systems, datalinks, and combat system integration of UAVs into surface ships.

Purpose

The purpose of this effort is to demonstrate the technical feasibility of integrating UAVs with combat systems elements and demonstrate C&I for command and control (C^2) of the land-based Hunter UAV. This effort will be referred to as the UAV SCSI demonstration program.

Concept of Operations

A fielded UAV for surface combatants would achieve operational interoperability through incorporation of C^2 concepts for a land-based Hunter UAV. This would provide USN, USMC, and USA forces with an organic, tactical, interoperable RSTA capability. The system concept for naval applications focuses on integrating Hunter UAV system software and hardware into ship subsystems. Thus, USN and USA forces may either operate a Hunter UAV using organic C^2 assets or share resources and exchange air vehicles with another Service's control stations. The air vehicle would be capable of carrying imaging sensors common with the Hunter UAV, incorporating the Hunter UAV C^2 and video downlink to ensure interoperability. Hunter UAV system software will be hosted on an existing USN Tactical Advanced Computer-III. An existing USN Light Airborne Multi-Purpose System (LAMPS) MK-III AN/SRQ-4 datalink will be modified to operate the Hunter UAV.

The UAV SCSI program is examining and reducing technical risks associated with the areas of datalink, software rehosting, and combat systems integration. The major element in the SCSI program is:

- To demonstrate system integration. Ship topside space is very limited, and additional weight adversely affects ship stability. Additional datalink equipment would impact systems already deployed. Use of existing antennas is the optimum solution to this problem, and studies have indicated that the AN/SRQ-4 may be comparable with the Hunter UAV datalinks. The systems integration effort will integrate a modified AN/SRQ-4 with a Tactical Advanced Computer-III based workstation that will host Hunter UAV software. A prototype MPCS and the modified AN/SRQ-4 will be integrated with the Hunter UAV for flight demonstrations. A phased demonstration approach consisting of modeling, system integration, test bed simulations, hardware-in-the-loop demonstrations, land-based flight tests, and shipboard demonstrations is planned.

Status

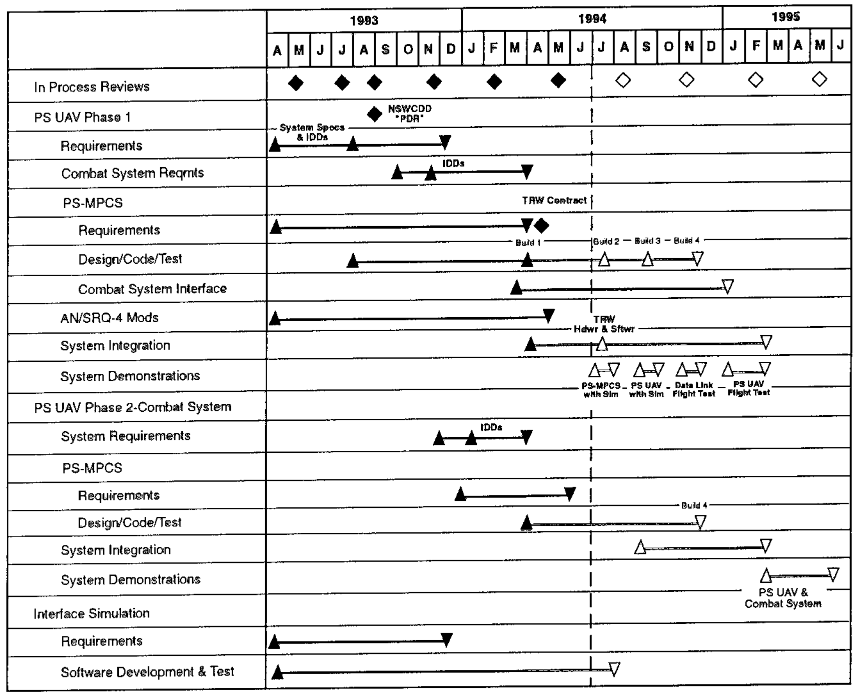
The SCSI program is proceeding with a shipboard datalink (LAMPS MK III), a prototype ship (PS)-MPCS, and combat system elements on USN Aegis, DD-963, and L-class ships. Several current efforts are underway that relate to the UAV SCSI program; each is outlined below:

- AN/SRQ-4 modification - The LAMPS MK III Ship Data Terminal (SDT) is being modified to enable communication with the Hunter UAV Block 0 air vehicle. The objective is to develop this SDT so that no modifications are required in the air vehicle. The PS-MPCS will provide the necessary message protocol and bit processing to the modified LAMPS MK III SDT

for transmission to the air vehicle

- AN/SRQ-4 modification testing - Naval Air Warfare Center-Aircraft Division (NAWC-AD), Patuxent River, MD will perform government testing of the modifications of the AN/SRQ-4 data link, which will be installed at the rotary wing ship ground station. A Hunter UAV air data terminal (ADT) will be installed in an H-60 helicopter, and two-way communications between the AN/SRQ-4 at the ship ground station and the ADT in the H-60 will be evaluated

- Systems Integration Laboratory (SIL) - The SIL for the JT UAV Program at Huntsville, AL will be used to conduct various tests to ensure integration and interoperability between the PS-MPCS demonstration system and the Hunter UAV system



LEGEND
IDDs = Interface Design Documents
NSWCDD = Naval Surface Warfare Center Dahlgren Division
PDR = Preliminary Design Review
PS-MPCS = Prototype Ship Mission Planning and Control Station
PS-UAV = Prototype Ship UAV

Figure 3-25 UAV SCSI Schedule

- TRW/IAI will be responsible for the Hunter UAV elements being used in the PS UAV demonstration system (air vehicle and flight control box). TRW/IAI will rehost the existing Hunter UAV datalink and flight control box link management software to ensure integration into the PS UAV demonstration system

- Advanced Tomahawk Weapons Control Station (ATWCS) Development - ATWCS is currently under development. The hardware and software development environments being used for ATWCS will be used in this demonstration system to allow for future integration of the Hunter UAV demonstration system function into the ATWCS

- AEGIS and Tomahawk Experiments - Experiments are being conducted that allow for the standard AEGIS computers to interface with USN standard workstations through a Naval Surface Warfare Center, Dahlgren, VA development programmable network interface unit. This effort and a fiber-optic connection between Aegis and Tomahawk facilities will be leveraged for developing the test bed capabilities for the UAV SCSI effort.

Schedule

The schedule for the SCSI demonstration program is shown in Figure 3-25.

3.3.7 Tilt Rotor UAV System (TRUS)

Background

The TRUS offers an attractive combination of rotary and fixed wing technologies (see Figure 3-26). This combination makes it well suited to support the long range and high speeds required for over-the-horizon targeting for ship missile systems and RSTA for USMC fire support elements while having the VTOL capability required for small combatant ship operations.

The two-phased TRUS program was developed in response to Congressional direction to provide the opportunity to evaluate Tilt Rotor/Wing UAV technology for a wide variety of missions. Phase I was a four-month nondevelopmental technical and engineering study effort that concluded in April 1992. Phase II focused on the development and fabrication of two tilt rotor air vehicles and a flying qualities and performance evaluation of tilt rotor technology. The prime contractor is Bell Helicopter Textron Incorporated, Fort Worth, TX. A table of desired TRUS characteristics is in Appendix B.

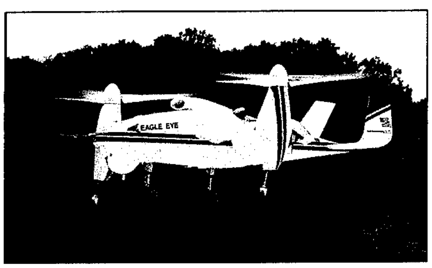


Figure 3-26
Tilt Rotor UAV

Status

First flight of a TRUS air vehicle occurred in early July 1993, after less than one year of development. Factory flight testing was successfully completed in November 1993. Phase II concluded early in February 1994, with the successful completion of flight testing at the Yuma Proving Ground, AZ.

During 1993, the TRUS air vehicle successfully demonstrated hover, VTOL capability, forward and lateral translations, climbs, descents, and banked turns. During the flying qualities and performance demonstration in January and February 1994, the TRUS air vehicle accomplished several successful transitions from helicopter mode to full airplane mode. Maximum speed achieved in airplane mode was 159 knots, with maximum bank angle of 48 degrees in turns while in airplane mode. In all, the TRUS flew 3 hours over 14 flights at the factory and 8.5 hours over 11 flights at Yuma Proving Ground. Additional flight testing will be accomplished at the NAWC-AD, Patuxent River, MD in June 1994. A final test report will be available at the end of June 1994.

3.3.8 Vertical Launch and Recovery (VLAR) UAVs

Background

The purpose of this demonstration program is to assess a variety of VLAR UAV technologies. Candidates include jet lift, tilt rotor, vertical attitude aircraft, stopped rotor, helicopters, ducted fan, and tilt wing (see Figure 3-27 on previous page). This program was established in response to FY93 Congressional direction. However, funding was withheld by the OSD Comptroller until August 1993.

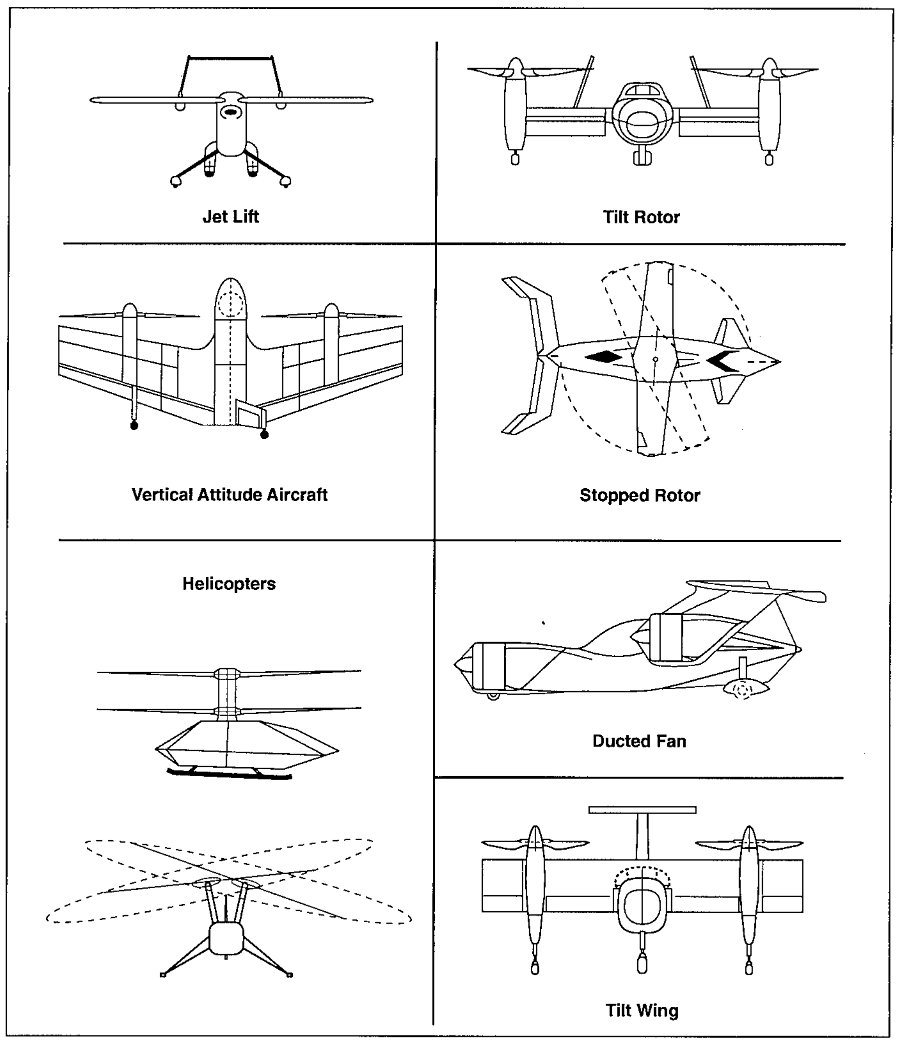


Figure 3-27 VLAR Candidate Technologies

One or more of these air vehicle technologies is being competitively selected for contract award(s) to demonstrate and evaluate basic flying qualities and performance parameters. Requirements and objectives for a VLAR system are shown in Appendix B.

Status

Activities completed include:

- Requests for information (RFIs) issued in September 1992 soliciting information from industry on VLAR air vehicle concepts
- A competitive RFP issued in September 1993
- Proposals received in November 1993
- One contract was awarded on 22 May 1994 to Boeing Corp., Seattle, WA for demonstration of a verticle attitude aircraft called "Heliwing."

The plans for 1994 include:

- Nine month studies/air vehicle fabrication/flight test preparation phase
- Air vehicle(s) demonstration(s). Each contractor will conduct a 3 week, or 15 range hour, flying qualities and performance demonstration at Yuma Proving Ground, AZ.

3.3.9 Activities with the UGV JPO

Background

A memorandum of agreement (MOA) addressing the working relationship between the UAV JPO and the UGV JPO was signed in June 1993. The MOA applies to common and complementary mission concepts, C&I of hardware and software, and joint demonstrations of capabilities. An initial joint technical experiment was successfully conducted in September 1993 using the STV UGV and the Pointer Hand Launched UAV.

The purpose of the technical experiment was to:

- Demonstrate objective technical interfaces between UGV and UAV systems
- Pass UAV control data by fiber-optic cable to the UGV, then uplink it to the UAV
- Pass UAV video data via downlink to the UGV, then through a fiber-optic cable to the ground control unit
- Document experiment results (technical report and video tape) and findings, including all operational and technical issues related to UGV/UAV integration.

Status

Planning for follow-up joint technical experiments and other activities in 1994 is underway. The intent is to exchange technical information and to enhance the coordination, management, and technical processes between two major players in the overall DoD robotics effort.

3.3.10 Activities with the Physical Security Equipment Management Office (PSEMO) and the Air Mobile Ground Security System (AMGSS) Program

Background

The PSEMO manages all DoD security equipment and has a wide variety of security-related projects for all the Services. The AMGSS program is managed by the PSEMO and funded by OSD. The UAV JPO has been working closely with Naval Command, Control and Ocean Surveillance Center Research, Development, Test and Evaluation (RDT&E) Division (NRaD), the technical team leader of the AMGSS program. An MOA addressing possible working relationships between the UAV JPO and the PSEMO has been drafted concerning areas of common interests between the two offices. The AMGSS is a ground-based system designed to provide rear area ground security. The mission requirements of AMGSS are to enhance the effectiveness of rear area physical security and force protection and to be capable of VTOL operation from unprepared areas and of being unloaded, assembled, and repacked by two persons.

Status

The AMGSS is a three phased demonstration program. Phase I was a platform technology demonstration and remote operation concept study. Phase II involves platform modification/design and demonstration. Phase III will consist of platform system integration and field testing. A table of AMGSS system characteristics is in Appendix B. A broad agency announcement for the AMGSS VTOL UAV platform was released in May 1993. Three contracts were awarded for Phase I: Sikorsky Aircraft, Stratford, CT, with a ducted coaxial helicopter, and McDonnell Douglas Aircraft, Mesa, AZ and the Stratos Group, Fairfax, VA, both with versions of a vertical attitude aircraft. Phase I was completed in January 1994. A report of results will be available in the summer of 1994.

3.4 MEDIUM RANGE UAV SYSTEM

3.4.1 Background

On 11 March 1985, the USN and the USAF signed an MOA on tactical reconnaissance development activity. This MOA assigned responsibility to USAF for developing EO imagery sensors for tactical reconnaissance equipment and the USN responsibility for the concept definition of unmanned tactical reconnaissance vehicles.

In accordance with the Tactical Air Forces 301-87 statement of operational need for day-night/all-weather tactical reconnaissance sensor package, dated 17 December 1987, USAF was charged with developing the tactical reconnaissance package for installation in the MR UAV. The system was designated the advanced tactical air reconnaissance system.

On 8 July 1985, the Secretary of the Navy promulgated an UAV program decision memorandum directing the procurement of a mid-range RPV for tactical reconnaissance. An RFP covering a competitive prototype development phase was released on 25 August 1986. Subsequently, two engineering analysis contracts were awarded in August 1987. At the completion of these contracts a resolicitation was issued to meet the urgent requirement to acquire an affordable and effective MR system either as part of a joint RPV/target program or, if deemed more cost effective, as a stand-alone MR program. An RFP for the engineering and manufacturing development of an MR UAV was released on 29 June 1988.

The MR UAV program was reviewed at a Navy Program Decision Meeting. An Acquisition Decision Memorandum dated 28 June 1989 granted Milestone (MS) II approval to enter the engineering and manufacturing development phase for the reconnaissance vehicle, but not for the target variant.

In April 1991, the USN Service Acquisition Executive and the DoD UAV EXCOM approved initiation of the risk reduction portion of a redefined program leading to contract modification approval on 10 June 1991. On 10 December 1991, the DAB approved the redefined MR UAV program resulting in the Acquisition Decision Memorandum being signed on 3 January 1992.

On 23 June 1993, the USAF announced that it would end its contract with Martin Marietta, Orlando, FL for development of the advanced tactical air reconnaissance system for the MR UAV due to technical difficulties and late deliveries.

3.4.2 Purpose

Military operations have shown severe tactical deficiencies in the collection of near real-time reconnaissance data at radii of up to 350 nm/650 km. Further, as enemy forces become more mobile and weapon system technology advances, the gathering of tactical reconnaissance data by manned aircraft will become increasingly difficult and more hazardous. Tactical commanders need the capability to acquire real, or near real-time, reconnaissance data, day or night, in increasingly higher threat environments, routinely and quickly. The MR UAV was being developed as an organic, low-cost, highly survivable asset that could collect EO/IR data on fixed targets at radii up to 350 nm, day or night, and provide these data to tactical commanders in near real time.

The MR UAV system was intended to provide multimission support to the C^3I efforts required to conduct joint operations in support of reconnaissance, target acquisition, and BDA.

3.4.3 Status

The program completed risk-reduction efforts and the critical design review (CDR) for the redefined program. The risk reduction effort involved contractor flight testing of two graphite composite vehicles with developmental reconnaissance payloads. The first powered flight of the MR UAV was conducted in May 1992. A second air-launched mission in July 1992 demonstrated autonomous flight, imagery collection, and recovery. A successful ground launch in February 1993 completed the risk reduction phase of testing. Preliminary design reviews on both the vehicle and ground launcher were conducted in 1992, and the CDR was conducted in June 1993. The CDR was closed out in October 1993. Figure 3-28 shows ground launch of the MR UAV.

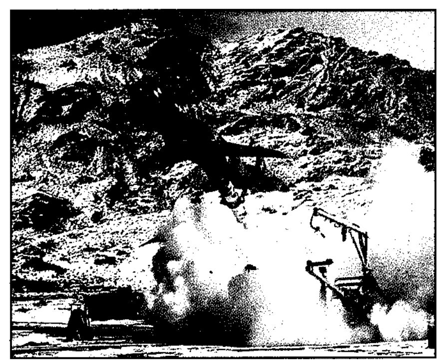


Figure 3-28
MR UAV Ground Launch

In late October 1993, the government accepted the first MR UAV metallic air vehicle from the prime contractor, Teledyne Ryan Aeronautical, at their facility in San Diego, CA. Subsequently, the MR program was terminated in accordance with USD(A) Acquisition Decision Memorandum dated 29 October 1993. The MR UAV was determined to be "not affordable given its priority within the UAV family and resources available."

ACRONYMS (Section 4)

ADT	Air Data Terminal
C^3I	Command, Control, Communications, and Intelligence
C^4I	Command, Control, Communications, Computers, & Intelligence
C&I	Commonality and Interoperability
CAG	Common Avionics Group
CARS	Common Automatic Recovery System
DIS	Distributed Interactive Simulation
DoD	Department of Defense
DOF	Degrees of Freedom
DSI	Defense Simulation Internet
FY	Fiscal Year
GCS	Ground Control Station
GDT	Ground Data Terminal
JDF	Joint Development Facility
JII	Joint Integration Interface
JTC/SIL	Joint Technology Center/Systems Integration Laboratory
JT UAV	Joint Tactical UAV
MICOM	Missile Command (USA)
MMP	Modular Mission Payload
MPCS	Mission Planning and Control Station
PEO	Program Executive Officer
RDEC	Research, Development, and Engineering Center
RF	Radio Frequency
SIF	System Integration Facility
SIL	Systems Integration Laboratory
UAV JPO	Unmanned Aerial Vehicle Joint Project Office

4.1 OVERVIEW

The modern battlefield environment within which UAV systems must operate is complex and involves combined forces from various Service elements. The UAV JPO framework of strategies recognizes that UAV system C&I is basic to the successful acquisition of a family of affordable and operationally effective UAV systems. Commonality is the ability to identify and capitalize on opportunities for savings and efficiencies through the use of interchangeable systems, subsystems, and components within the UAV family and with other DoD programs. Interoperability is the ability of these systems to provide services to and accept services from other systems, and to use the services so exchanged to achieve effective combat operations. Commonality is a life cycle cost decision, while interoperability is an operational requirement. C&I concepts that shape the UAV JPO program are as follows:

- UAV systems must have many common functions and must share as much common equipment and associated software as practical to reduce life cycle cost and simplify logistics support functions
- UAV systems must be designed to fit into Service C^4I architecture so that they are effective in multi-Service and Unified Command operations
- UAV systems must allow for growth in performance and readily accommodate new component technologies in order to have long term utility in the field.

These concepts require a disciplined systems engineering approach to achieving C&I.

4.2 C&I APPROACH

4.2.1 Commonality

The UAV JPO commonality approach is to test and evaluate state-of-the-art component technologies (payloads, engines, avionics) and write performance specifications suitable for procurement in the domestic and international marketplaces. The key technology elements of the UAV commonality approach are illustrated in Figure 4-2 (see next page). Decisions to incorporate such technologies in existing UAVs such as the Hunter, as well as future UAV systems, will be made based on the results of appropriate cost-effectiveness analyses. A description of the technology developments and demonstrations managed by the UAV JPO is provided in Section 5 of this document.

4.2.2 Interoperability

Interoperability is achieved at three levels:

- Component - the ability to interface and operate subsystem components across the UAV family (e.g., interchangeable payloads)
- Category - the ability to operate air vehicle and payload subsystems from other UAV categories from any ground station
- Battleforce - the ability to operate and interface with specified C^4I systems.

The interconnections or standard interfaces necessary to achieve C&I are called joint integration interfaces (JIIs). The type and number of JIIs are determined by the UAV Capstone Specification, which defines the system architecture requirements for the UAV family. The architecture and JII development process are shown in Figure 4-1.

4.3 UAV ARCHITECTURE

The UAV Capstone Specification describes an architecture which enhances

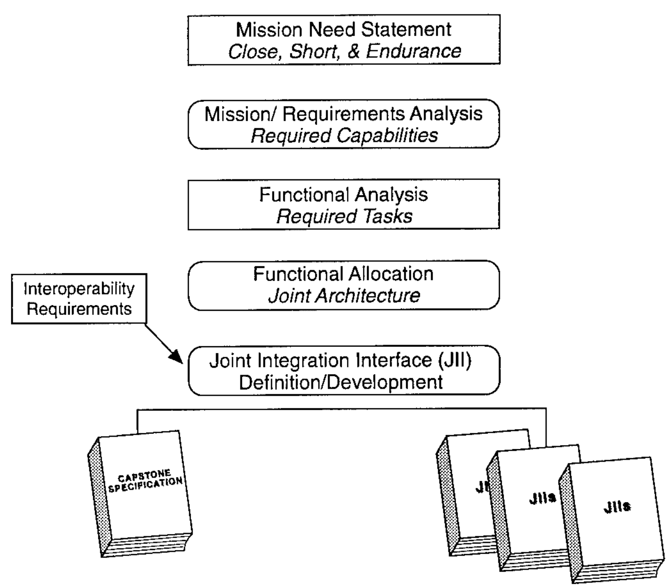


Figure 4-1 Architecture and JII Development Process

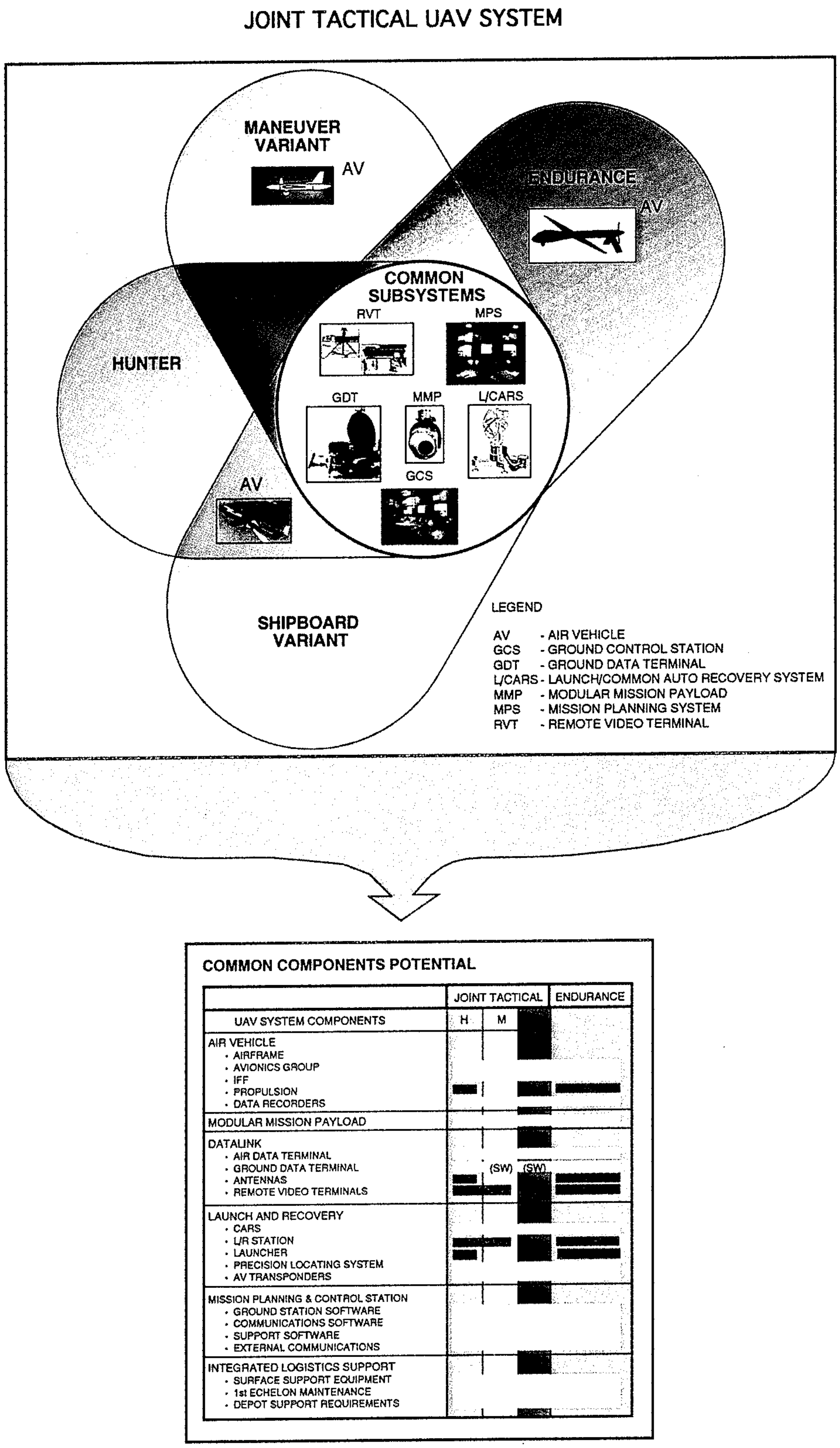


Figure 4-2 UAV Commonality Approach

hardware/software C&I among several UAV categories, between systems, and with external C^4I assets. The term architecture is defined as a minimum set of rules and constraints governing the availability, arrangement, interaction, and interdependence of the parts or elements that together may be used to form a system that satisfies a specific set of requirements. Furthermore, the Capstone Specification incorporates the technical guidelines which shall govern the development of future systems comprising the UAV family. As the UAV family acquisition continues, the Capstone Specification will be updated to address an open interoperability architecture where all interfaces required to achieve interoperability are standardized. As a guidance document, it advocates, via appropriate specifications and standards, an open system environment in which computer systems and software of different vendors are interchangeable, thus reducing cost and providing increased UAV communications capability. This architecture presumes that all UAVs utilize a compatible (not necessarily a common) datalink which can communicate with any other UAV system.

4.4 JOINT INTEGRATION INTERFACES

A JII is defined as any interface, internal or external to the UAV family of systems, that is identified, defined, and controlled by the UAV JPO to ensure required system C&I. JIIs provide the interface framework required to ensure C&I. Figure 4-3 illustrates the currently defined JIIs and their relationship relative to the UAV system.

Each JII is divided into two sections, baseline and growth. The baseline section documents the information contained in the baseline Hunter UAV. Since the Hunter UAV is a nondevelopmental item and did not exhibit sufficient capability to satisfy future UAV family growth requirements (e.g., new payloads, automatic landing), a growth section was added. It consists of five types of control and five types of status messages with varying rates of transmission.

The following four sets of interfaces or JIIs have passed verification testing: (1) mission planning and control station (MPCS) to ground data terminal (GDT), (2) air data terminal (ADT) to air vehicle which combines the ADT to common avionics group (CAG) and ADT to modular mission payload (MMP), (3) CAG to MMP, and (4) CAG to air vehicle. With the exception of the MPCS/external communications JII, the other JIIs depicted in Figure 4-3 will undergo appropriate levels of verification testing at the UAV JPO JTC/SIL in FY95. The JIIs shown in Figure 4-3 are described as follows:

- CAG to Air Vehicle - This JII describes the interfaces between the air vehicle avionics and other air vehicle systems, such as those for flight controls, engine controls, and navigation

- CAG to MMP - This JII contains the messages required to allow the use of each payload developed for use throughout the UAV family

- MPCS to Launch and Recovery - This JII is primarily associated with the CARS of the UAV. The positional and velocity information of the air vehicle and the recovery platform, measured by the precision tracker in the recovery system, is routed over this interface to accomplish au-

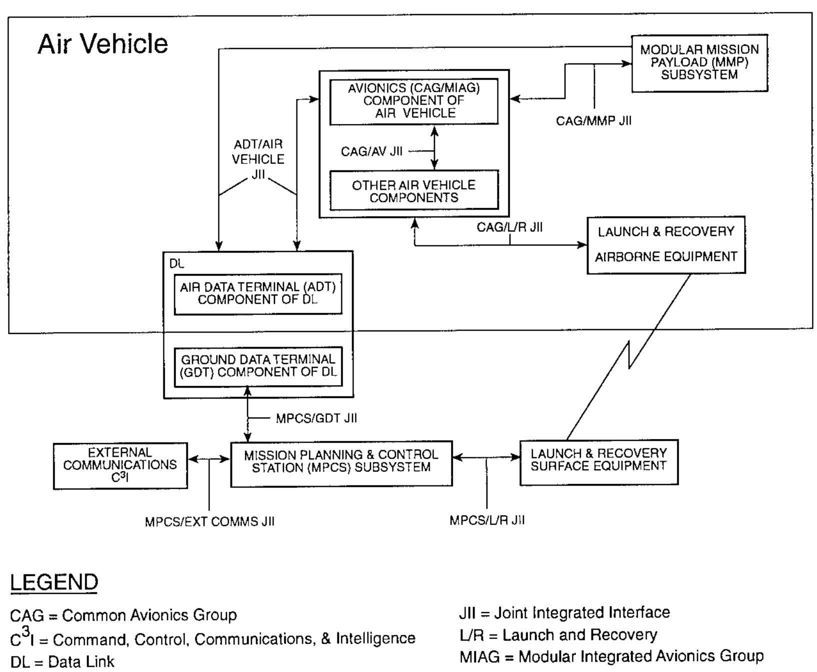


Figure 4-3 UAV System JII Diagram

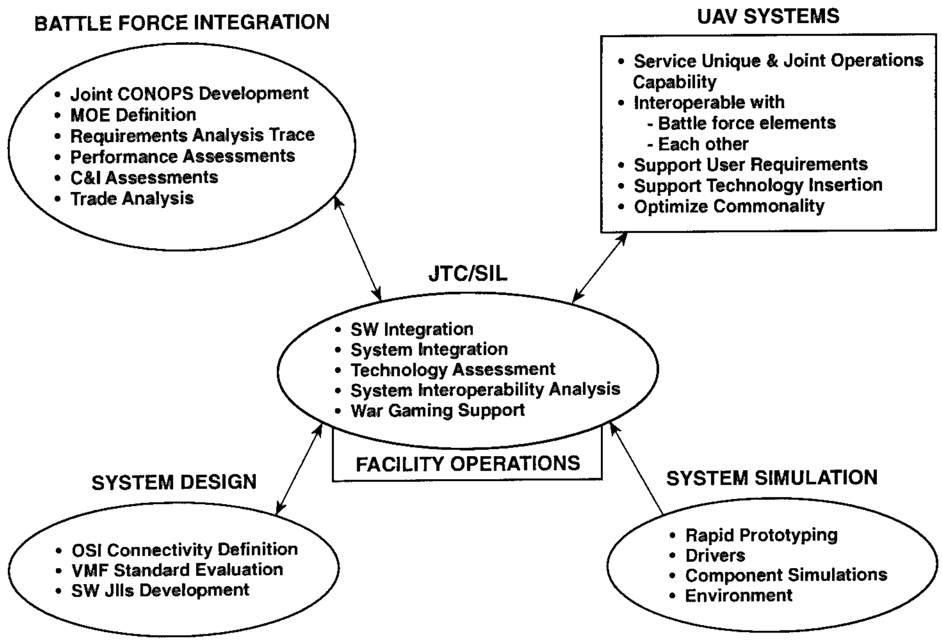


Figure 4-4 C&I in the JTC/SIL

tomatic recovery

- Launch and Recovery to CAG - This JII permits the autoland precision tracker to provide positional and velocity information (generated in the precision tracker) to be routed directly to the CAG (autopilot/automatic flight control) in the air vehicle. This JII enables the precision tracker to operate exclusive of the datalink

- MPCS to GDT - This JII is required to permit the control of any air vehicle and its payloads from any family GCS. It provides a description and signal definition of all datalink inputs and outputs

- MPCS to External Communications - This JII permits operational tasking and coordination from the UAV ground component and the command and control nodes of external C^4I systems

- ADT to Air Vehicle - This JII is the airborne equivalent of the MPCS to GDT JII. It defines two separate interfaces, the ADT to CAG and the CAG to MMP. Navigation, mission programming, air vehicle control, and payload control are accomplished using this interface.

4.5 JOINT TECHNOLOGY CENTER/SYSTEMS INTEGRATION LABORATORY

The JTC/SIL was officially established in February 1994 at the USA Missile Command (MICOM) Research, Development, and Engineering Center (RDEC) at Redstone Arsenal, AL as the Center of Technical Excellence for the joint family of UAVs. The purpose of the JTC/SIL is to provide simulation, integration, and a full range of test support to the joint UAV family. As illustrated in Figure 4-4, the JTC/SIL plays a critical role in facilitating C&I. The JTC/SIL provides cohesiveness by linking system design, system simulation, system integration, technology insertion, and battle force inte-

gration for all UAV systems.

The JTC/SIL focus is on supporting UAV programs in resolution of technical issues associated with C&I; system integration; C^3I; operational concept and doctrine development; and future UAV developments and product improvements. The JTC/SIL provides for technology assessment, insertion, demonstration, and transfer; C&I support; and open system interconnectivity architecture design and test; as well as a central database for UAV test results and "lessons learned." Analysis, virtual prototyping, simulation, and testing (bench, hardware-in-the-loop, tower, captive flight, and free flight) conducted in the JTC/SIL at the direction of program managers and the UAV JPO will result in substantial risk reduction, cost savings, and improved performance. JTC/SIL personnel are conducting front-end analysis and testing of new designs, payloads, and product improvements, and providing recommendations to program managers prior to submission to a prime contractor for integration. The JTC/SIL is a mechanism for UAV participation in Commander-in-Chief, Battle Lab, and other technical and operational demonstrations and exercises through the War Breaker and Defense Simulation Internet (DSI). In addition to facilitating resolution of interoperability procedures, interfaces, and tactics, use of the resources of the JTC/SIL early in the program will ensure each program manager a smooth transition to post-deployment support. As illustrated in Figure 4-5, the SIL simulation strategy is designed to support each program manager from concept definition through product improvement.

The JTC/SIL consists of three primary facilities, each of which is briefly described below and depicted in Figure 4-6 on the next page.

System Integration Facility (SIF)

The SIF provides tactical component hardware for hardware-in-the-loop testing and integration of subsystems and software. The SIF features integrated tactical components in a tactical configuration employing the actual tactical communications interfaces. As new UAV system tactical hardware is installed in the SIF, additional or modified hardware/software assets will be provided as necessary to meet the demands of the program managers and other users. The SIF is the primary facility for accomplishing integration of advanced payloads for inserting

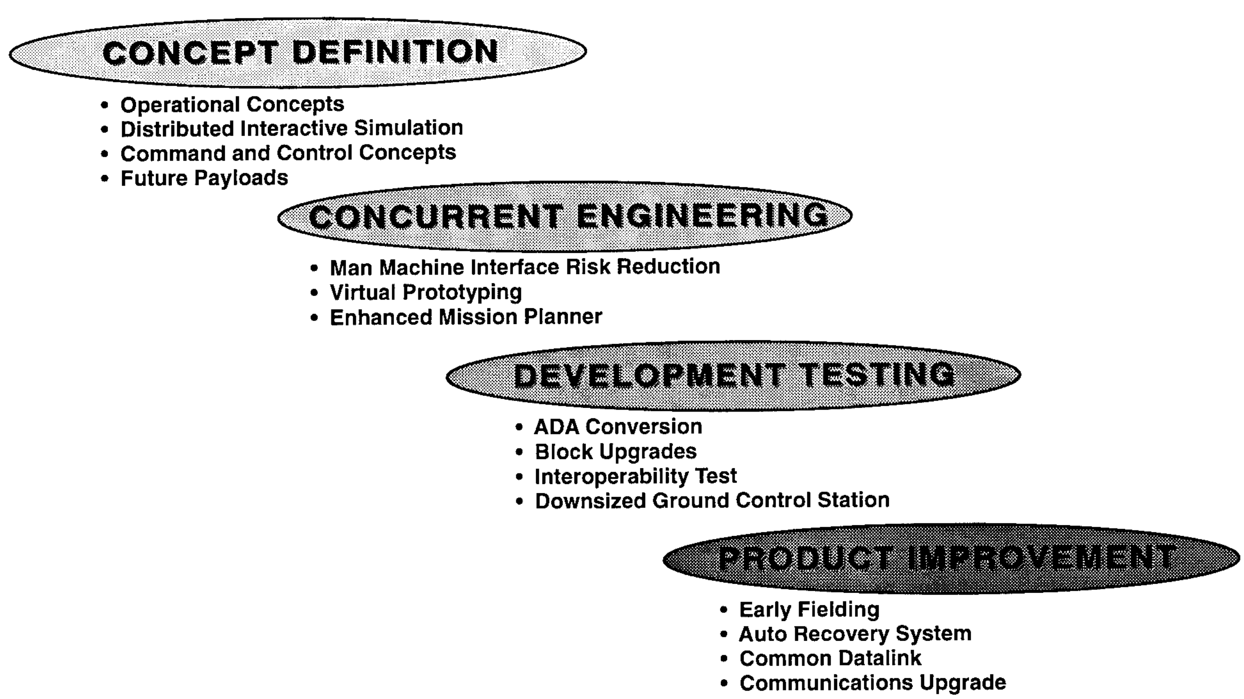


Figure 4-5 JTC/SIL Simulation Support

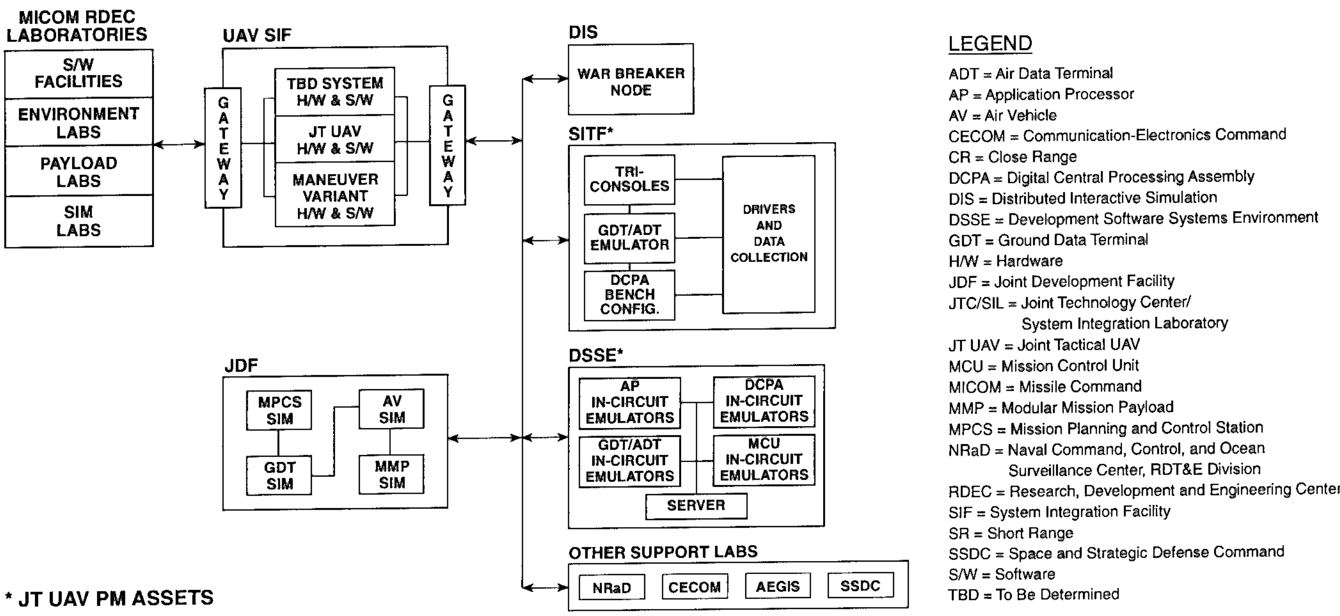


Figure 4-6 UAV JTC/SIL

new technologies into UAV systems.

Distributed Interactive Simulation (DIS) Facility

This facility provides a realistic UAV system-level simulation with connectivity to DIS networks (currently interfaced with War Breaker and projected to interface with DSI). This system of hardware includes the capability to model the air vehicle with three degrees of freedom (DOF). More detailed information on the DIS Facility is provided in Section 6.2.

Joint Development Facility (JDF)

The JDF forms the core of the modeling and simulation capability, providing an independent subsystem simulation and JII simulation capability. The system features a modular architecture to allow for rapid prototyping and insertion of new components and simulations. The JDF can provide a realistic representation of actual or proposed system(s) that will support evaluations of proposed systems or system upgrades in a constructive or virtual simulation environment. In addition, when coupled with the DIS Facility, the JDF can support operational concept and doctrine development.

Complementing the capabilities of the JTC/SIL, JT UAV program owned facilities such as a life cycle software engineering center will be collocated with the SIL as they are developed and delivered. In addition, a software reuse library will be part of the facility. The JTC/SIL staff and associated technical experts serve as the facilitators of action for the PEO and the UAV program managers and work with the users and prime contractors. Through cross-utilization and efficient management of common assets, the maximum product development and support to the program managers will be accomplished in a cost-effective manner.

Also available to JTC/SIL customers are facilities managed within the MICOM RDEC structure. These include payload test towers; state-of-the-art simulation laboratories; hardware-in-the-loop center for microwave, millimeter wave radio frequency (RF), infrared, and electro-optical guided systems; test ranges; the DIS Facility; and gateways to the DSI and other laboratories. These RDEC capabilities will be coordinated and scheduled for JTC/SIL users as required, as well as expertise required from laboratories of all Services.

The JTC/SIL is an integral part of the UAV JPO systems engineering process, which defines the functional characteristics of system hardware, software, and facilities, and translates them into design requirements during the life cycle of the UAV systems.

ACRONYMS (Section 5)

ADM	Advanced Development Model
ADT	Air Data Terminal
APU	Auxiliary Power Unit
ARPA	Advanced Research Projects Agency
AUVS	Association for Unmanned Vehicle Systems
CARS	Common Automatic Recovery System
CARS-P	Common Automatic Recovery System Prototype
CDL	Common Data Link
COMINT	Communications Intelligence
COMM	Communications
DoD	Department of Defense
DOE	Department of Energy
ECM	Electronic Countermeasure
EIP	Engine Improvement Program
ELINT	Electronics Intelligence
ESM	Electronic Support Measure
FCT	Foreign Comparative Testing
FLIR	Forward Looking Infrared
FY	Fiscal Year
GCS	Ground Control Station
GPS	Global Positioning System
HFE	Heavy Fuel Engine
IFF	Identification, Friend or Foe
IMINT	Imagery Intelligence
IMU	Inertial Measurement Unit
IR	Infrared
JEWC	Joint Electronic Warfare Center
JROC	Joint Requirements Oversight Council
JT UAV	Joint Tactical UAV
MAVUS	Maritime VTOL UAV System
MET	Meteorological
MIAG	Modular Integrated Avionics Group
MICOM	Missile Command (USA)
MOA	Memorandum of Agreement
MPCS	Mission Planning and Control Station
NASA	National Aeronautics and Space Administration
NAWC-AD	Naval Air Warfare Center - Aircraft Division
NBC	Nuclear, Biological and Chemical
NRaD	Naval Command, Control, and Ocean Surveillance Center RDT&E Division
NSA	National Security Agency
ONR	Office of Naval Research
PEO(IEW)	Program Executive Officer, Intelligence and Electronic Warfare
RADIAC	Radioactivity Detection, Indication, and Computation
RDEC	Research, Development and Engineering Center
RDT&E	Research, Development, Test, and Evaluation
RFI	Request for Information
RPV	Remotely Piloted Vehicle
SAR	Synthetic Aperture Radar
SBIR	Small Business Innovation Research
SIGINT	Signals Intelligence
SSG	Special Study Group
UAV JPO	Unmanned Aerial Vehicle Joint Project Office
UGV	Unmanned Ground Vehicle
UGV JPO	UGV Joint Project Office
UHF	Ultra High Frequency
USA	United States Army
USMC	United States Marine Corps
VHF	Very High Frequency
VTOL	Vertical Takeoff and Landing
ZEOP	Z-Electro-Optical Payload

5.1 OVERVIEW

Three of the UAV JPO strategy elements specifically address technology assessment and demonstration:

- Improve fielded UAVs through incremental technology upgrades of subsystems

- Use risk reducing demonstrations of new UAV technology to speed the introduction of improvements

- Stimulate exploratory and advanced technology development that has the potential to enhance future UAV performance and affordability.

The expanse that these technology strategies must encompass is extremely broad and includes payloads, power generation, propulsion, automated air vehicle recovery, flight controls, datalinks, air frames, and mission planning. Budget resources that the UAV JPO can devote to this arena are extremely limited. Accordingly, UAV JPO actions must capitalize on the technology developments of the Services, other DoD agencies, and industry. A five part execution approach is employed to accomplish this.

1. Collaborate with the ARPA, Office of Naval Research (ONR), and Service laboratories to identify and coordinate UAV related technology development efforts.

Technology management and evaluation processes have been established to ensure effective utilization of existing programs and capabilities, avoid redundant development activities, and institute a coherent technology program. A Joint Technology Steering Committee, chaired by the UAV JPO, with ARPA, ONR, NSA and Service laboratory membership, has been formed. The function of the Joint Technology Steering Committee is to identify, monitor, and coordinate UAV-related technology development efforts.

2. Collaborate with government and industry to identify opportunities to evaluate component technology for common application to the family of UAV systems.

MOAs between the UAV JPO and a variety of agencies have been completed or are being negotiated. They include ARPA, ONR, the Department of Energy (DOE), NASA, the Joint Electronic Warfare Center (JEWC), the Program Executive Officer, Intelligence and Electronic Warfare (PEO (IEW)), and NSA. The UAV JPO utilizes the Association for Unmanned Vehicle Systems (AUVS) and briefings to professional societies as forums for government and industry information exchange.

3. Conduct laboratory experimentation to determine maturity and feasibility associated with integration of developing UAV component technologies.

4. Demonstrate and evaluate matured UAV component technologies to determine suitability, effectiveness, and risk associated with application to UAV family requirements.

5. Transition component technology to UAV systems in the form of low-risk, development specifications derived from UAV JPO technology performance evaluations.

5.2 PAYLOAD DEMONSTRATIONS

Table 5-1 provides the growth payload requirements of the Services for the family of UAVs. This list of payloads has not yet been prioritized by the JROC's SSG.

SERVICE REQUIREMENTS *			
	USA	USMC	USN
Hunter UAV	COMINT Comm/Data Relay Comm Jammer ELINT Laser Designator MET Sensor Mine Detection MTI Radar NBC Detection Non-Comm Jammer SAR	Comm/Data Relay ECM ELINT Laser Designator MET Sensor Mine Detection NBC Detection	COMINT Comm/Data Relay Comm Jammer ECM/Decoy ELINT Laser Designator MET Sensor Mine Detection NBC Detection Non-Comm Jammer SAR
Maneuver Variant UAV	COMINT Comm Jammer ELINT Laser Designator MET Sensor MTI Radar Non-Comm Jammer SAR	Comm/Data Relay Comm Jammer ECM/Decoy Laser Designator MET Sensor	
Endurance UAV	COMINT Comm Jammer ELINT Laser Designator MET Sensor MTI Radar Non-Comm Jammer SAR	Comm/Data Relay Comm Jammer ECM/Decoy Laser Designator MET Sensor	

* Listings are not prioritized

LEGEND

COMINT = Communications Intelligence
ECM = Electronic Countermeasure
ELINT = Electronic Intelligence
MET = Meteorological
MTI = Moving Target Indicator
NBC = Nuclear, Biological and Chemical
SAR = Synthetic Aperture Radar

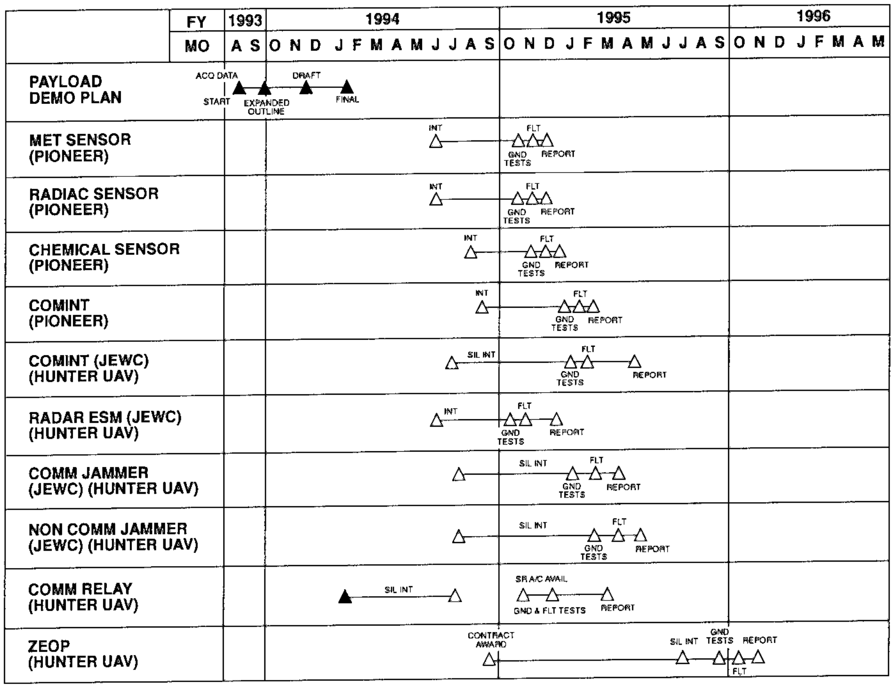
Table 5-1
Growth UAV Payloads
(not prioritized)

5.2.1 Payloads for Evaluation in FY94 and FY95

Figure 5-1 (see next page) provides the schedule of the growth payloads that are being demonstrated beginning in FY94. The primary objective of the demonstrations will be to determine the performance boundaries of these payloads for the Hunter UAV, the Maneuver Variant, and the endurance UAV. The choice of payloads being demonstrated was driven by funding constraints, ease of payload availability, and UAV platform availability.

Meteorological (MET)

A UAV MET sensor is capable of mea-



LEGEND

COMINT = Communications Intelligence
COMM = Communications
ESM = Electronic Support Measures
FLT = Flight
GND = Ground
INT = Integration
JEWC = Joint Electronic Warfare Center
MET = Meteorological
SIL = System Integration Laboratory
ZEOP = Z Electro-Optical Payload

Figure 5-1 Payload Demonstrations (FY94)

suring and computing the variables affecting atmospheric conditions over a relatively large area. It can provide more accurate and complete meteorological information than has been available from other types of current MET data collection systems. The primary advantage of a UAV collection system is the capability to comprehensively sample meteorological conditions over a wide area rather than the single point data gathering capability of current systems. Better weather forecasting will improve:

- UAV flight management
- Use and delivery of battlefield obscurants
- Monitoring of NBC agents
- Artillery fire adjustment
- Prediction of communication equipment and sensor performance
- Mission planning.

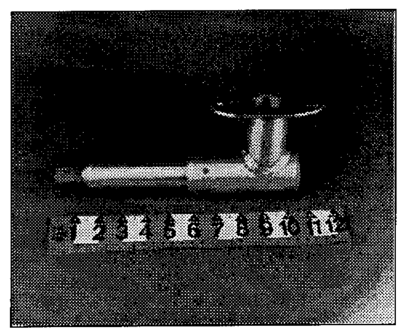
Civilian UAV applications include:

- Studying and forecasting weather phenomena and patterns
- Detecting and tracking pollutants.

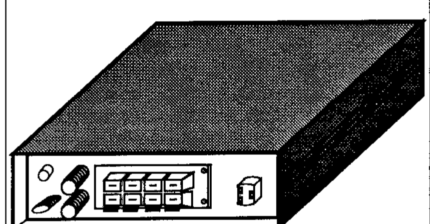
The UAV JPO plans to interface a two-lb MET sensor (the sensor from a balloon radiosonde integrated with a digital interface unit) to the Pioneer UAV's datalink. Atmospheric data samples, along with air vehicle information, will be downlinked to Pioneer's GCS. The payload can also be utilized in the Hunter UAV; integration and testing are expected in FY94. Figure 5-2 shows key elements of the MET sensor.

Radioactivity Detection, Indication and Computation (RADIAC) Detection Sensor

An airborne RADIAC sensor is needed to rapidly detect, measure, and record residual ground gamma radiation dose rates from standoff ranges. Without exposing its operator to harm from the radiation, a UAV RADIAC payload can detect, measure, and display the aerial radiation dose



MET Probe



Digital Interface Box

Figure 5-2
MET Sensor

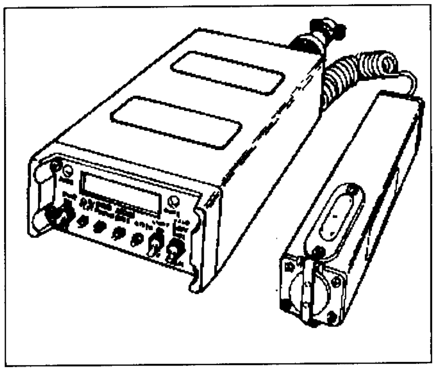


Figure 5-3
Nuclear Radiation Detection Sensor

rate, compute the contaminated ground radiation dose rate, and map out the affected area(s). This would provide a relatively rapid and accurate hazard warning to personnel. Civilian applications of a UAV RADIAC system could include airborne monitoring of nuclear power plants and nuclear waste disposal sites.

The airborne RADIAC program has been under development by the USA Communications and Electronics Command. An enhanced RADIAC set (AN/VDR-2), called Advanced Airborne RADIAC System, was tested onboard an OH-58C Kiowa Warrior helicopter by the USA in 1991. The system weighs approximately 5 lbs. See Figure 5-3.

The Advanced Airborne RADIAC System integration into the Pioneer UAV and its airborne testing will be conducted in FY94.

Chemical Agent Detection

A critical Service need exists for an unmanned chemical agent(s) detector. This sensor can be used to plot the area of suspected toxic agents so that corrective chemical decontamination procedures can be implemented in a timely manner.

A Lightweight Standoff Chemical Agents Detector was funded by the USMC through the USA's Edgewood Research, Development, and Engineering Center, Aberdeen Proving Ground, MD. The 26-lb payload is capable of detecting toxic materials when operating from a moving airborne platform. See Figure 5-4. The Lightweight Standoff Chemical Agents Detector's design is based on an infrared Michelson interferometer and modern signal processing techniques. The USMC integrated it into a helicopter and conducted tests in 1993.

Communication Intelligence (COMINT)

The Services have a need for a COMINT UAV payload that can intercept enemy communication emissions. In an earlier effort, a DoD user developed a lightweight (20-lb payload) COMINT receiver for special applications. See Figure 5-5. In 1993, the UAV JPO investigated the feasibility of adapting this receiver for UAV applications and determined such an effort was feasible. This COMINT payload will be integrated into a Pioneer UAV for flight testing in 1994.

The UAV JPO and the JEWC are collaborating on the integration and test of a second COMINT payload on the Hunter UAV in 1994. This 30-lb payload will provide wide frequency coverage, precision direction finding, high sensitivity, and accurate geolocation of threats.

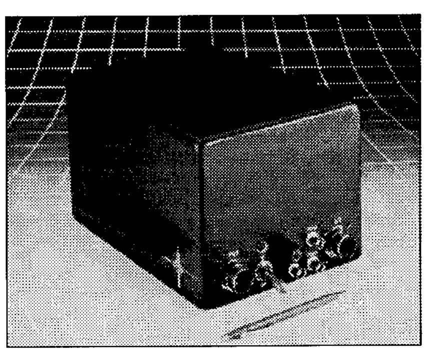


Figure 5-4 Chemical Agent Detector

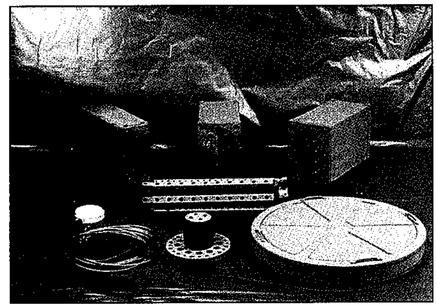


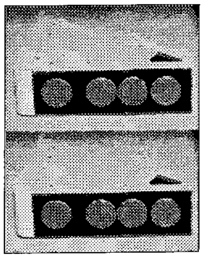
Figure 5-5 COMINT Payload

Radar Electronic Support Measure (ESM)

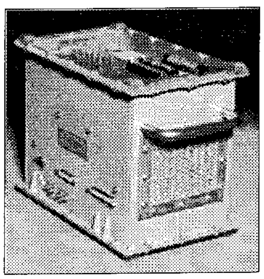
Radar ESM systems collect information for immediate tactical use. They are generally smaller, more mobile, and less sophisticated than the COMINT system. Operational commanders employ an ESM system to search, intercept, identify, and locate sources of radiated electromagnetic energy that will provide immediate recognition of the threat. The UAV JPO and the JEWC are collaborating on the integration and test of a 20.3-lb ESM payload on the Hunter UAV in 1994. Figure 5-6 shows the components of the ESM system (see next page).

Communications (COMM)/ Non-Communications (Non-COMM) Jammers

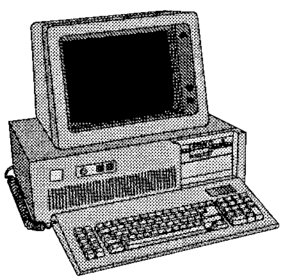
The Services require a system to detect, identify, locate/track, and target threat radars. Comm/non-comm jammers will complement the Services' current manned SIGINT collection assets by building a comprehensive picture of the enemy's electronic order of battle. In particular, these electronic countermeasures (ECM) payloads will assist in the destruction of enemy air defense by suppressing enemy air defense radars.



Two 8 Elements Sector Array



Receiver



Stand Alone
Ground Processing Station

Figure 5-6
Radar ESM Payload

The UAV JPO and the JEWC are collaborating on the development of two ECM payloads for UAVs. The communication jammer payload will be programmable to generate various ECM waveforms against a variety of threats, and it will operate against all frequencies of interest. The non-communication jammer payload will also be programmable to generate different waveforms for maximum effectiveness against radar threats. A 98-lb non-communication jammer and a 47.5-lb communication jammer are scheduled for integration and testing in 1994 on the Hunter UAV.

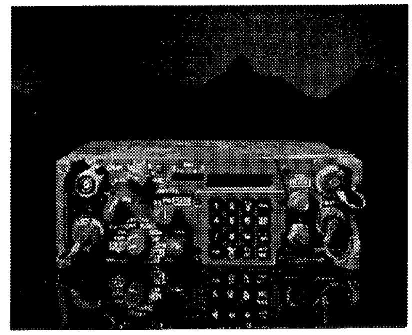
Communications Relay

A Service operational requirement exists for a UAV communications relay to support future operations where the distance between commanders and subordinate units may extend hundreds of kilometers beyond current link capabilities. Hunter UAVs, deployed with communications relay payloads, will provide the required communications range extension and permit force mobility over all types of terrain.

In 1992, the USA Signal School identified an urgent need for a UAV communications relay. The UAV JPO, working with USA and USMC users, determined which near-term communications relay technology was suitable and feasible for application in UAVs. Initial actions included obtaining a single-channel VHF ground and airborne radio system relay, packaged by the RDEC, Huntsville, AL, and an off-the-shelf four channel UHF relay, an RT-460. The combined package weighs approximately 70 lbs. See Figure 5-7. It will be integrated into the Hunter UAV testbed for evaluation during the first half of 1994.

Lightweight Autotracking Dual Television / Forward Looking Infrared Payload

A longstanding operational requirement exists for an all-weather, day/night imagery intelligence sensor. A dual-sensor payload, combining both TV and FLIR into a lightweight gimbaled package (50 lbs or less), can fulfill this need. An autotrack feature to both improve UAV operational effectiveness and reduce operator workload is desired.



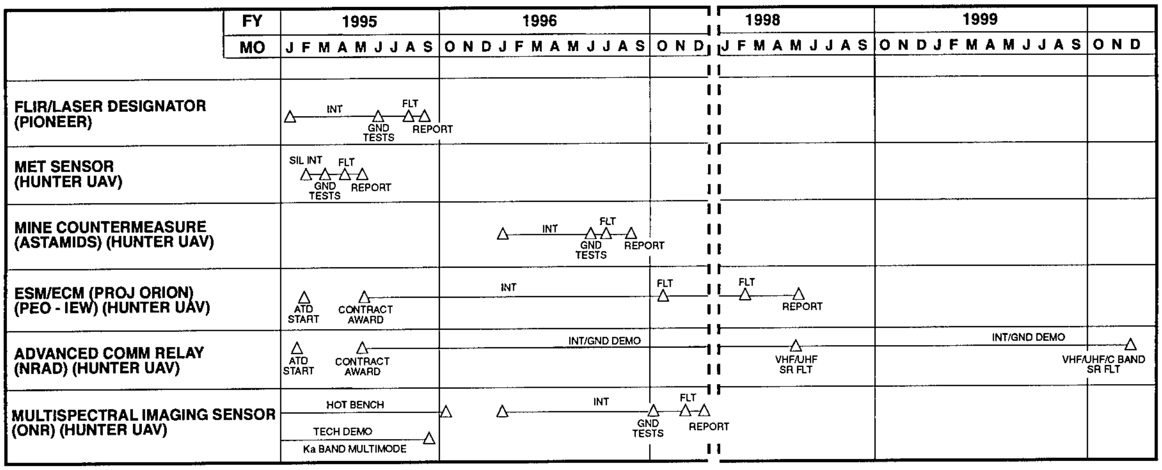
SINCGARS Radio Relay

RT-460A UHF Relay

Figure 5-7
VHF/UHF Communications Relay

The UAV JPO conducted a demonstration of lightweight FLIR technology in 1991. Rafael, Haifa, Israel was one of the contractors to demonstrate its FLIR. Subsequent to the demonstration, Rafael enhanced its basic FLIR payload by combining a TV and the FLIR into a stabilized, autotracking gimbaled system that weighs less than 50 pounds. Consequently, the UAV JPO nominated Rafael's Z-Electro-Optical Payload (ZEOP) for Foreign Comparative Testing (FCT) and it was approved.

Two ZEOPs will be procured from Rafael in FY94. The ZEOP will be integrated into the Hunter UAV for flight testing and evaluated on its suitability for UAV application in FY95 (see Figure 9-3 in Section 9).



LEGEND

ASTAMIDS = Airborne Standoff Minefield Detection System
ATD = Advanced Technology Demonstration
CECOM = Communications-Electronics Command
COMM = Communications
ECM = Electronic Counter Measures
ESM = Electronic Support Measures
FLIR = Forward Looking Infrared
FLT = Flight
GND = Ground
IEW = Intelligence & Electronic Warfare
INT = Integration
JEWC = Joint Electronic Warfare Center
MTI = Moving Target Indicator
NRaD = Naval Command, Control and Ocean Surveillance Center RDT&E Division
ONR = Office of Naval Research
PEO = Program Executive Officer
UHF = Ultra High Frequency
VHF = Very High Frequency

Figure 5-8 Payload Demonstrations (FY95 and Beyond)

5.2.2 Growth Payloads

The UAV JPO plans to evaluate additional payloads for use with UAVs. In cooperation with other organizations such as USA PEO(IEW), NRaD, and ONR, the UAV JPO is developing plans to evaluate the growth payloads according to the tentative schedule shown in Figure 5-8.

5.3 ENGINES AND POWER GENERATION

An operational requirement exists to develop and procure engines that use heavy fuels (JP5 and JP8) for air vehicle propulsion and ground power generation. APUs provide power to MPCSs and require mobility, portability, and efficiency while also operating on heavy fuels. The following HFE and APU programs are important elements of the UAV engine technology program:

HFE Program

The HFE Program was initiated in 1989. Three lightweight engine designs were investigated to address the stringent UAV heavy fuel technology goals. Validation testing of the three approaches by the NAWC-AD, Trenton, NJ indicated that a significant advancement in the state-of-the-art technology had been achieved and that its feasibility had been demonstrated. The final report documenting these results will be published in the third quarter FY94. Figure 5-9 shows one of the three HFEs evaluated.

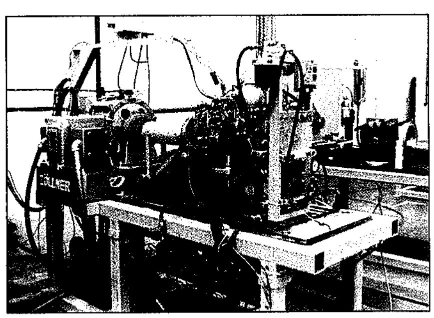


Figure 5-9
Heavy Fuel Engine

Responsibility for maturing, integrating, and fielding a HFE for the Hunter UAV has been given to TRW, the system integration contractor. TRW is in the process of selecting an HFE subcontractor to support the program. It is a Block II upgrade to the Hunter UAV as described in Section 3.1.6.

Engine Demonstrations - The CL-227 Engine Improvement Program (EIP)

The purpose of the CL-227 EIP is to validate a small, multifuel turboshaft engine for VTOL and conventional fixed wing UAV applications. Turbine engines provide optimum performance for VTOL platforms and are more reliable and require less maintenance than reciprocating or rotary engines. Initially, Williams International, Walled Lake, MI designed their WTS-117 engine for the USA Forward Area Aerial Defense System Program. As a proactive measure for early testing, an internal design goal of Williams was to make the engine form-fit compatible with the existing WTS-34 engine currently used in the CL-227 Sentinel. The characteristics of these engines are shown in matrix form in Appendix B.

A contract award to Canadair Inc. (Williams International as subcontractor) is expected in May 1994. The contract includes the design, development, and fabrication of two enhanced turboshaft engines and one enhanced fuel tank. One engine and one fuel tank will be installed in a CL-227 air vehicle for flight testing and performance evaluation.

This modified CL-227 is viewed as an interim step towards achieving a six-hour endurance capability. This program also serves as a "first step" towards developing a recuperative engine, a development that could lead to a common propulsion technology for VTOL and fixed wing UAVs.

UAV Recuperated Engine Demonstration

Currently, turbine engines do not have low enough brake specific fuel consumption to satisfy UAV engine performance requirements. A demonstration will be conducted at the NAWC-AD, Trenton, NJ with a Williams International recuperative turbine designed originally as a ground APU. The results will determine whether recuperated engine technology would be feasible in airborne vehicle propulsion applications. Generally, recuperated turboshaft engines have been too large and heavy for airborne applications, particularly for UAVs.

Recuperated engine technology involves using a recuperator (type of heat exchanger) in conjunction with small turbine engines to improve efficiency (reduced fuel consumption, particularly at partial power settings). If size and weight constraints can be met, significantly improved VTOL endurance (30-50% increase) over traditional turbines is expected along with the increased reliability inherent in turbine engines.

APU - 500 Watt

The lightweight, heavy fuel APU technology investigations support the development and acquisition of APUs for UAV ground equipment. In particular the Maneuver Variant UAV has an operational requirement for a one-person portable, heavy fuel APU. Appendix B shows key physical and performance requirements for the APU.

In FY93, the UAV JPO conducted an APU industry survey through an RFI. The assessment showed that development and testing of a prototype APU is required prior to acquisition since there are no off-the-shelf APUs that will satisfy the Maneuver Variant UAV requirements. The Soldier Power Team at Ft. Belvoir, VA built an open-frame, lightweight APU prototype. It consists of a lightweight (9-lb), direct injection, spark ignition, two-stroke engine developed by Ricardo Engineering, along with a motor generator, a muffler, and fuel/oil tanks. The prototype can run for 1 hour on JP-8 fuel, producing 21 volts DC. In 1994, the Soldier Power Team plans to enhance their prototype by enclosing it with sound absorption material, installing a 28-volt DC motor generator, increasing operational time to two hours, and improving cold start performance. A demonstration prototype unit will be available by the end of June 1994 for UAV JPO evaluation.

APU - 15+ Kilowatt (kw) System

The JT UAV Program has a requirement for generator sets producing 10-15 kw to provide power for UAV mission ground control stations. The purpose of this program is to develop prototype generator sets that provide at least 15 kw of power, weigh 300 lbs or less, and are capable of using heavy fuel. Many existing gensets run on gasoline; those that use heavy fuel are too heavy and bulky. A lightweight, compact, heavy fuel genset is desirable for military use and is also in demand commercially. Martin Marietta assembled a team from industry, academia, and government (UAV JPO) to submit a proposal for the development of a 15 kw lightweight generator system called PowerPak. The proposal was submitted to the ARPA under the dual-use Technology Reinvestment Project. A table showing the initial performance goals of PowerPak is found in Appendix B. In December 1993, ARPA awarded the PowerPak proposal to Martin Marietta. The Technology Reinvestment Project is planned to begin in April 1994 and last 18 months. The objective is to build, test, and demonstrate two prototype PowerPak APUs that meet the performance goals listed in Appendix B. In FY96, the Joint Tactical UAV Program plans to support test and evaluation of a prototype unit to determine if it meets UAV generator requirements.

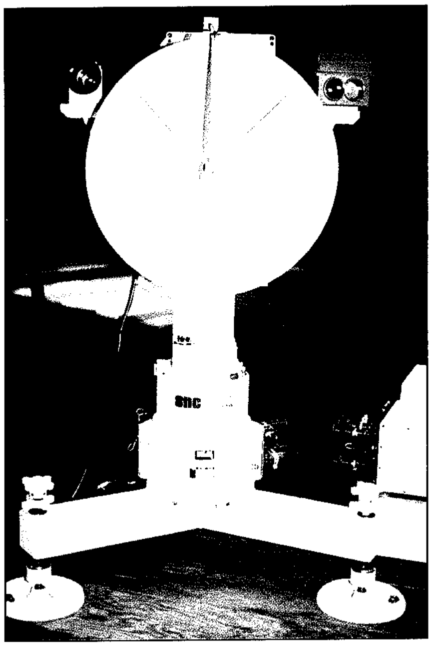


Figure 5-10
CARS-P

5.4 COMMON AUTOMATIC RECOVERY SYSTEM

A system for safe, reliable recovery of UAVs is required to reduce operational air vehicle losses and operational personnel training and proficiency maintenance. The Pioneer UAV recovery problems have highlighted some of the unique challenges in recovering UAVs at sea. Manual UAV recoveries require significant skills that are normally obtained through intensive training and/or experience. The CARS program was initiated to address these challenges. In 1990, the UAV JPO awarded a contract to Sierra Nevada Corporation, Sparks, NV to design, develop, and build a prototype unit called CARS-P. See Figure 5-10. This millimeter wave radar recovery system is being demonstrated as part of the CL-227 UAV in the MAVUS I and II programs. Precise automated recoveries with land dispersion of less than 1 foot have been demonstrated with MAVUS. The CARS-P is being demonstrated onboard the USS Vandegrift as part of the MAVUS II Program. This system is also planned for integration and fielding in the Hunter UAV as discussed in Section 3.1.6.

5.5 SUPPORTING TECHNOLOGIES

Modular Integrated Avionics Group (MIAG)

In 1989, the UAV JPO initiated the MIAG program to establish a common modular vehicle/flight management system and meet a critical need to reduce space and weight and improve performance of the baseline UAVs. The program objective was to develop a specification that would meet UAV family requirements. MIAG provides the following functions: flight control, navigation, guidance, and payload control. Lear Astronics Corporation, Santa Monica, CA was awarded a contract by the USAF Wright Laboratory to develop MIAG development specifications and build two advanced development models (ADMs). Due to budgetary constraints, the ADMs were not completed. In May 1993, the UAV JPO and ARPA established an MOA to complete the MIAG ADMs. ARPA agreed to complete the integration of the GPS and an inertial measurement unit (IMU) into the ADMs. The UAV JPO agreed to provide one ADM to ARPA for use in the UGV Demonstration II program. This program is being conducted by ARPA, Carnegie Mellon and Martin Marrietta under the auspices of the UGV JPO. The MIAGs are used principally for navigation in UGVs. In FY94, Lear Astronics Corporation will complete the integration of GPS/IMU into the MIAG ADMs. In addition to upgrading the two ADMs, ARPA will procure four additional ADMs to support their UGV Demonstration II program.

An RFI was released in early FY94 to assess technology regarding the practicality of integrating IFF equipment into MIAG. The MIAG specification, lessons learned in producing, testing, evaluating, and demonstrating the ADMs, and information obtained assessing the MIAG/IFF integration RFI will provide valuable guidance for engineering and manufacturing development of a common MIAG for UAVs.

Low-Cost Datalink

A common datalink is crucial in implementing DoD reconnaissance systems interoperability. The DoD CDL is currently the standard datalink for transferring SIGINT and imagery intelligence (IMINT) data between the Services' airborne reconnaissance assets and their ground exploitation systems. However, the DoD CDL is too heavy and too costly for UAV application.

UNISYS developed a lightweight derivative of the CDL ADT suitable for UAV use. The derivative weighs 18 lbs and can operate in either X or C band at ranges out to 80 miles. The UAV JPO and PEO (IEW) of the USA are collaborating to evaluate this prototype.

Under the direction of the UAV JPO, PEO (IEW)'s program manager for Airborne Reconnaissance Low integrated this datalink and two contractor-furnished sensors (Loral's Miniaturized Synthetic Aperture Radar and Loral's Stabilized Thermal Imaging System FLIR) into its Sherpa, C-23A testbed. In addition, a Guardrail ground station at Ft. Monmouth, NJ was modified to receive the SAR/IR imagery from the test bed via the lightweight CDL. Flight tests were conducted at Ft. Monmouth in December 1993 and will continue in 1994. Technology demonstration objectives of the flight test are to:

- Evaluate lightweight/low cost CDL technology for potential UAV application

- Design and test of a digital data link interface for SAR and FLIR imagery transmission/reception

- Implement and evaluate data compression for high-resolution SAR/IR imagery transfer while minimizing imagery quality degradation.

UAV Ice Protection System

Detection and prevention of icing on UAVs is a critical need. UAVs accrete ice more readily and at a faster rate than larger aircraft due to the smooth, thin airfoils that have inherently high ice collection efficiencies. The lack of deicing equipment for UAVs results in significant vulnerability to icing and/or reduced UAV availability due to adverse weather conditions. It is expected that future UAV requirements will include an all-weather capability. The UAV JPO recognizes that an extremely reliable system will be needed to meet this requirement. Acceptable technology must address reliable detection of ice accretion and then perform deicing, activate a "return-to-base" evolution, or alter the UAV flight path to avoid icing conditions.

The UAV JPO plans to investigate a combination of technologies and resultant equipment developments that could be applied to satisfying UAV ice protection requirements. An ARPA Small Business Innovation Research (SBIR) Phase II ice protection project is being monitored. Coordination with the developer and the USN's Pioneer UAV Program Office (PMA-263) is underway with a goal to integrate a closed-loop ice protection system into the Pioneer test bed for flight demonstration. In addition, an RFI was issued in November 1993 to determine the current state of ice protection technology and its application to UAVs. Eight companies submitted responses for evaluation from November 1993 to January 1994. Evaluation of submittals has been completed. A final assessment letter will be forwarded in May 1994.

5.6 UAV SMALL BUSINESS INNOVATION RESEARCH PROGRAM

The SBIR Program stimulates technological innovation by small businesses and increases commercial application of federally supported research results. It is a three-phase program. Phase I entails determining the scientific merit and feasibility of an idea (i.e., presents a fully developed concept and a plan of attack for pursuing Phase II objectives). Phase II is the principal research and/or development effort and is expected to produce a well defined deliverable product or process. Phase III supports conversion of the technology from government to commercial sector support.

The UAV JPO and its field activities have been major contributors of research topics awarded Phase I and Phase II contracts. The UAV JPO became involved with the SBIR process in 1990, and from the period of 1990 to mid 1993, a total of 21 Phase I contracts have been completed. The topics were:

- UAV Passive Propeller Load Control

- UAV Propeller Erosion Protection

- High-Energy Density, Long-Life, Secondary Battery Research and Development

- Innovative Small Engine Concepts

- Lightweight RPV Engine/Starter

- UAV Propulsion System Heat Exchanger Technology

- High Speed Diesel Fuel Injection Techniques

- Innovative Concepts for Directly Measuring Airflow in Internal Combustion Engines

- UAV Imagery Data Compression Algorithm

- Automation Tradeoffs Analysis Tool

- VTOL UAV for Maritime and Close Combat (two awards)

- Innovative Lightweight and Long Life Ignition Concepts for Low-Pressure Diesel Engines

- UAV VTOL Propulsion Concepts

- Nonintrusive Fuel Flow Measurement System

- Innovative Lightweight and Simple Fuel Filtration Concepts for Small Displacement Diesel Engines (two awards)

- UAV Engine Noise Suppression Techniques

- Innovative Unconventional Small Engine Concepts

- Ultra-Wideband Technology for UAV and Other Airborne Applications

- Using Neural Networks for Autonomous UAV Flight Operation and Mission Control.

In late 1993, the SBIR topic, Migrating Combustion Chamber Engine, was selected for a Phase II contract award. Also

in 1993, eight Phase I topics were approved for contract award; one has been awarded, three are in the process of being awarded, and the remaining four are being negotiated.

- Government Wide/Paramilitary Applications of UAVs (two awards)
- Neural Filtering for Active Noise Suppression for Diesel Engines
- Automatic Target Recognition/ Cueing Using a UAV Multispectral Imaging Sensor
- Conceptual Design of Hybrid Diesel/Electronic Propulsion System
- Innovative and Durable Flexible Shafts for Power Transmission in UAV Propulsion System
- UAV Electronic Decoy Payload
- Performance Optimizing Full Authority Digital Engine Controls for High Speed Assisted Diesels.

Two Phase I Topics advertised during Program Solicitation 94.1 have completed proposed evaluation. This resulted in three recommendations for contract award approval.

- Low-Cost, Fault-Tolerant Flight Controls for UAVs
- Small Lightweight Electric VTOL UAV. (2 Recommendations)

Four UAV Related Topics are in the process of being awarded Phase II contracts:

- High Energy Density, Long-Life Secondary Battery Research and Development
- Deep Water Pinger Location System
- Ultra-Wideband Technology for UAVs
- Low-Cost Magnetic Attitude Heading Reference System.

Three Phase I Topics Were Selected by ONR for Program Solicitation 94.2 Advertisement:

- Low-Cost, Lightweight, Night Vision Capability for Hand Launched UAVs
- UAV Meteorological Sensors for Atmospheric/Environmental Sensing Applications
- Small Single Shaft, Gas Turbine Engine Application Study.

ACRONYMS (Section 6)

ARPA	Advanced Research Projects Agency
CONOPS	Concept of Operations
DIS	Distributed Interactive Simulation
DoD	Department of Defense
DOF	Degrees of Freedom
DSI	Defense Simulation Internet
GCS	Ground Control Station
JDF	Joint Development Facility
JII	Joint Integration Interface
JTC/SIL	Joint Technology Center/Systems Integration Laboratory
MICOM	Missile Command (USA)
MIL-STD	Military Standard
RFP	Request for Proposal
SIF	System Integration Facility
SIL	Systems Integration Laboratory
UAV	Unmanned Aerial Vehicle
UAV JPO	Unmanned Aerial Vehicle Joint Project Office
USA	United States Army

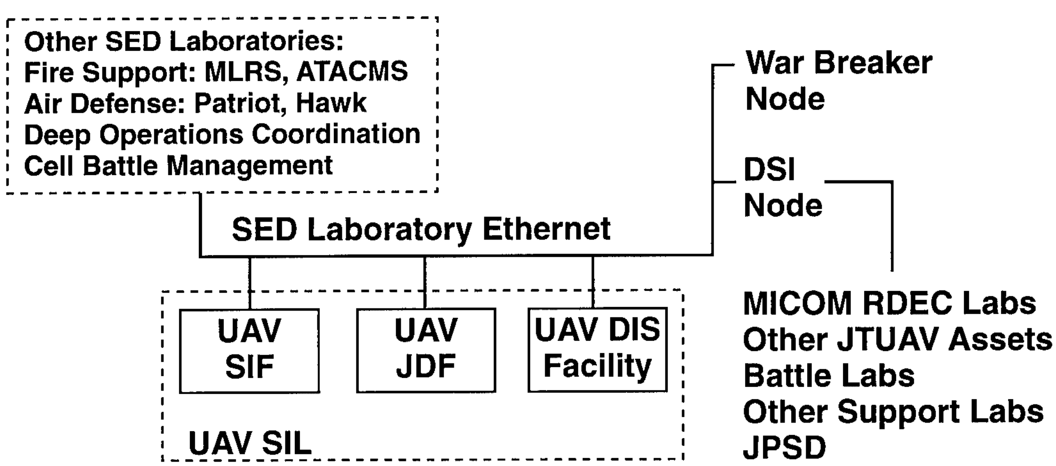
6.1 DISTRIBUTED INTERACTIVE SIMULATION

The UAV JPO has established the JTC/SIL to be the principal location for modeling and simulation supporting UAV development, as well as the focal point for DoD DIS. These capabilities allow users to define UAV requirements and concepts of employment and developers to evaluate engineering changes and prototype designs.

The SIL consists of a wide range of modeling and simulation tools that are constantly being expanded to accommodate needs of development engineers and combat users. The JDF consists primarily of a high resolution modular UAV simulation, designed initially to perform verification and validation of JIIs, that forms the core of the modeling and simulation capability. Existing simulation interfaces, such as air vehicles, payloads, and datalinks, are being modularized and placed in a users' library under configuration control. New simulations added to the SIL will also be added to the library. These modules can be combined into various configurations by users and developers wishing to evaluate new systems and subsystems in a constructive or virtual simulation environment. The JDF is augmented by the DIS Facility, a three DOF UAV simulation, previously known as the synthetic environment for requirements and concepts evaluation synthesis, or SERCES, which provides the SIL's initial DIS capability. Connectivity between the DIS Facility and War Breaker will be established by mid-1994 to support ongoing exercises. The JDF is to be interfaced to the DIS environment by early 1995.

Complementing the JDF and DIS Facility simulations is the System Integration Facility (SIF), a hardware-in-the-loop environment consisting of laboratory hardware, subsystem drivers, and UAV tactical assets. The SIF will be capable of driving the UAV GCSs, payloads, air vehicles, and datalinks. As part of its final implementation, the SIF will be interfaced to the JDF and be capable of operating in a DIS environment.

Through the use of the MICOM Software Engineering Directorate's laboratory ethernet and its connection to both the War Breaker network and the DSI (see Figure 6-1), the simulation capabilities of the UAV JPO are connected to many of the major simulation sites at both military and commercial facilities. This allows the insertion of UAVs into war games and analyses at USA Battle Labs; War Breaker; Joint Precision Strike Demonstration; Joint Theater Missile Defense; Louisiana Maneuvers; the Naval Command, Control and Ocean Surveillance Center; and programs such as the Synthetic Theater of War. This involvement with ARPA and all the Services allows UAV technical personnel to keep abreast of the latest distributed simulation technologies and applications to the UAV family.



LEGEND

ATACMS = Army Tactical Missile System
DIS = Distributed Interactive Simulation
DSI = Defense Simulation Internet
JDF = Joint Development Facility
JPSD = Joint Precision Strike Demonstration
JT UAV = Joint Tactical UAV
MLRS = Multiple-Launch Rocket System
RDEC = Research, Development & Engineering Center
SED = Software Engineering Directorate
SIF = System Integration Facility

Figure 6-1 SIL Connectivity

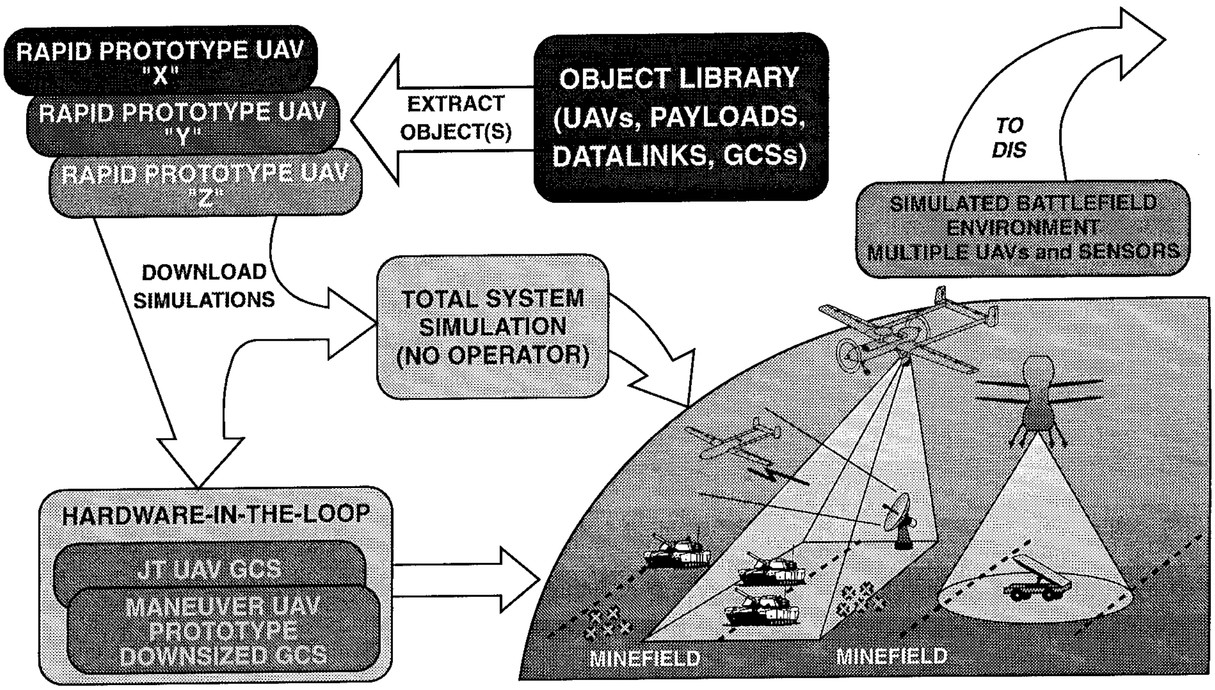


Figure 6-2 Concept Definition Through Simulation

Concentration of state-of-the-art technologies and UAV simulation and emulation capabilities in the SIL provides a powerful and cost effective tool for use in the development of various UAV platforms and advanced payloads. The use of DIS to tie these capabilities to other simulation sites results in an environment in which users, engineers, logisticians, and testers can examine requirements statements, CONOPS, and designs within the confines of a laboratory without ever bending metal. Virtual prototyping and testing of proposed interfaces can be done using digital simulations with various hardware components-in-the-loop as available. This DIS capability also allows participation of multiple UAV variants in major exercises at reduced costs and without using scarce tactical hardware. Figure 6-2 provides an illustration of this in a simulated battlefield environment. The purpose of this initiative is to change the acquisition process. Instead of a sequential, linear process in which requirements lead to a design specification that leads to a contract specification, etc., the objective is an iterative process that constantly improves. This is achieved using multiple feedback mechanisms that allow the developer, tester, and user to work together from the beginning of the acquisition process. This results in a better understanding of requirements tradeoff issues and should reduce the acquisition cycle time, costs, and risks. It also provides for more efficient horizontal and vertical integration of UAVs on the battlefield.

6.2 AUTOMATED SYSTEMS ENGINEERING MANAGEMENT PROCESS

The UAV JPO has now embarked on an effort to automate the entire systems engineering process and bring automated document creation and configuration management to the individual UAV program offices. The systems engineering management process is based on MIL-STD-499B and is to reside on the UAV JPO's local area network. The goal of this effort is to dramatically reduce the time and energy spent by core program office staff in creating, tracking, and managing configurations of primary acquisition documents. By integrating the process with previously developed tools such as those discussed above (e.g., SIL applications), strides can be made in the area of putting needed engineering information in the hands of the program manager and his staff in a timely manner. This type of tool is a great productivity enhancer in areas as diverse as responding to a congressional inquiry and ensuring design adequacy prior to RFP release. Specific goals for 1994 are to:

- Automate management of the systems engineering process:

- Identify what key systems engineering tasks are to be executed throughout the system's life cycle

- Tailor applicable standards based on requirements and subsequent requirements traceability for contractual application

- Automate systems analysis and control by developing:

  - Systems effectiveness assessments derived from data requirements

  - Modeling and simulation techniques to determine requirements verification and validation, including the traceability of the UAV JPO systems requirements throughout all applicable acquisition documentation (including contractor deliverables)

  - Current measures of effectiveness hierarchy and their respective traceability to requirements

  - Utility curves for each of the measures of effectiveness determined, providing a curve that presents the relative value of achieving a level of performance between the threshold and objective values for each measure of effectiveness

  - Assessment of technical risk including criteria and methodologies to be employed

  - The identification of key trade studies to be accomplished, including decision metrics to be utilized

- Ensure participation in the planning, design evolution, and design change process. This automated systems engineering management process assists the UAV JPO in maintaining a continuing focus on life cycle cost and provides system engineering management reports, technical performance measurement reports, and cost schedule reports.

ACRONYMS (Section 7)

ACAT	Acquisition Category
C&I	Commonality and Interoperability
CM	Configuration Management
CMIS	Configuration Management Information System
DoD	Department of Defense
HSI	Human Systems Integration
ILS	Integrated Logistics Support
JII	Joint Integration Interface
JLA	Joint Logistic Assessment
JLAWG	Joint Logistics Assessment Working Group
JL-COE	Joint Logistics-Center of Excellence
JL-MIS	Joint Logistics-Management Information System
JLSC	Joint Logistics Systems Center
JT UAV	Joint Tactical UAV
JULMT	Joint UAV Logistics Management Team
JULWG	Joint UAV Logistics Working Group
LSA	Logistics Support Analysis
MAE	Medium Altitude Endurance
MER	Manpower Estimate Report
MICOM	Missile Command (USA)
MOA	Memorandum of Agreement
MS	Milestone
OSD	Office of the Secretary of Defense
PEO	Program Executive Officer
PEO(CU)	Program Executive Officer, Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project
PICA	Primary Inventory Control Activity
UAV	Unmanned Aerial Vehicle
UAV JPO	Unmanned Aerial Vehicle Joint Project Office
USA	United States Army
USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy

7.1 JOINT INTEGRATED LOGISTICS SUPPORT (ILS)

7.1.1 Overview

The UAV JPO logistics mission in 1994 is to support the acquisition and early fielding of UAV systems. This Section applies to all UAV programs for which the UAV JPO has responsibility and includes the JT UAV program, Pointer, EXDRONE, MAE, and Pioneer UAVs. The total quality leadership management philosophy embodied in this mission involves liaison with the program managers, the Services, and DoD. The focus is on understanding how customers' needs can best be accommodated. The acquisition and logistics requirements are being reviewed and consolidated, and functional support is being provided to enhance the accomplishment of joint logistics program requirements. This translates into active, continuous participation to identify and resolve joint issues that impact logistics program management. The consideration and resolution of joint logistics issues is the single most important goal in 1994.

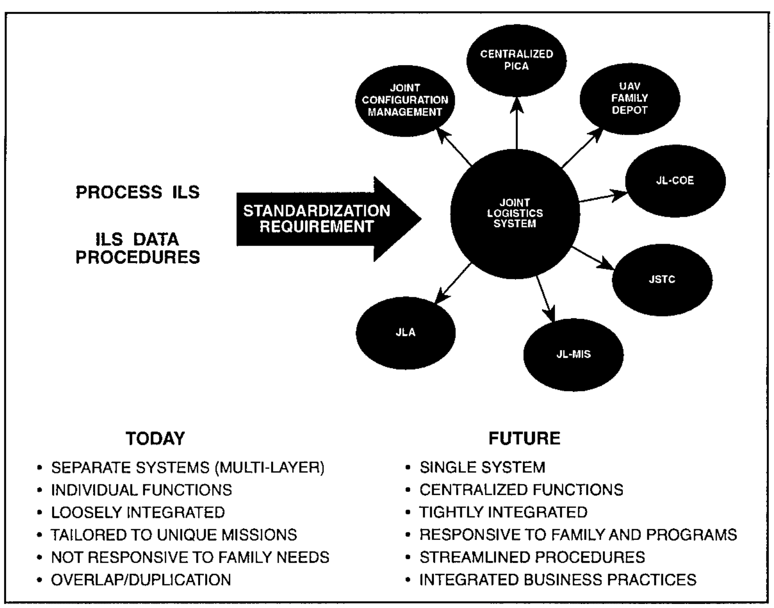
Initiatives for improving UAV JPO ILS management continue to emerge from actions begun in 1992 and prior years. Building on 1993 accomplishments and lessons learned, the 1994 plan expands the horizon for a UAV JPO logistics support team. This team will consolidate the technical and logistics expertise needed to effectively fulfill core logistics responsibilities to our supported program managers. The 1994 logistics initiatives are to:

- Strengthen the opportunity for greater logistics commonality
- Improve support elements on operation and maintenence of UAV systems across the Services
- Improve logistics infrastructure elements
- Provide logistics life cycle cost savings for the UAV family.

The UAV JPO is undertaking an extensive review of logistics processes to find more effective ways of providing logistics support to UAV programs. At the heart of this strategy is an action agenda that includes several initiatives to enhance logistics management support to the acquisition managers, and ultimately the Services, for deployed systems. The primary purpose is to improve logistics efforts by identifying and exploiting opportunities for joint Service cooperative efforts across the entire logistics spectrum. Figure 7-1 shows the UAV JPO evolutionary process. To support this purpose the following broad concepts serve as a guide:

- Prevent unnecessary duplication and promote economy of resources
- Streamline policies and standardize logistics concepts and procedures in those areas having potential for high logistics payoff
- Improve logistics support of UAV systems
- Streamline, standardize, and share logistics data throughout the UAV community
- Plan for the future.

The overriding goal is to become more customer oriented through a team concept that will use the best functional talent of the Services to focus on cradle-to-grave management of all UAV systems with our program managers. Planned proactive 1994 logistics activities, in concert with the Services and the program managers, provide and document a strong



LEGEND
ILS = Integrated Logistics Support
JLA = Joint Logistics Assessment
JL-COE = Joint Logistics-Center of Excellence
JL-MIS = Joint Logistics-Management Information System
JSTC = Joint Service Training Center
PICA = Primary Inventory Control Activity

Figure 7-1 UAV JPO Logistics Process Evolution

foundation for logistics process improvements. The joint logistics initiatives to be pursued during 1994 include the following:

- Joint UAV Logistics Working Group (JULWG)
- Joint Logistics-Center of Excellence (JL-COE)
- UAV Family Depot Policy
- Joint Logistic Assessment (JLA)
- Centralized Primary Inventory Control Activity (PICA) for UAVs
- Joint Configuration Management
- UAV Logistics Lessons Learned Repository
- UAV Logistics Management Guidance and Procedures
- Joint Logistics-Management Information System (JL-MIS)
- Joint UAV Training.

7.1.2 Joint UAV Logistics Working Group

A JULWG, comprised of representatives from each of the Services, OSD, and the Joint Logistics Systems Center (JLSC), is being chartered to continually improve acquisition logistics processes and to plan for enhanced operational logistics support to potential field/fleet units. Agreement on a draft MOA has been reached, and the JULWG is being established. Ideas for logistics process improvement are being sought not only from internal sources but also from the Services and program managers. Improvement initiatives are building on lessons learned and successes experienced with other programs. The JULWG is exploring efforts to improve logistics C&I and ensure the coordination and integration of logistics support capabilities to provide effective and responsive support to our customers. The efforts of this group focus on logistics activities that serve to meet UAV JPO and OSD objectives for improved system support, readiness, and sustainability. The JULWG, in concert with the Joint Logistics Assessment Working Group (JLAWG), is also conducting reviews of the UAV logistics programs with a view to exploring common efforts, identifying shortfalls, and developing candidate initiatives for endorsement to the PEO.

7.1.3 Joint Logistics-Center of Excellence for UAVs

The Joint Logistics Commanders in 1992 concurred with the UAV JPO recommendation for a JL-COE for UAVs and approved the Integrated Materiel Management Center of USA MICOM in Huntsville, AL as the JL-COE activity. The JL-COE is the primary logistics activity to support the UAV family of systems, stressing common, broad principles and procedures to plan, manage, and execute the logistics programs for the UAV family of systems. It is responsive to each UAV program manager for negotiated levels of logistics support. The JL-COE, in partnership with selected Service activities, provides a fully integrated team of ILS functional talent to support each UAV program. This partnership of logistics expertise will become exceptional as the JL-COE concept matures and Service programs are brought under the joint umbrella of JL-COE support.

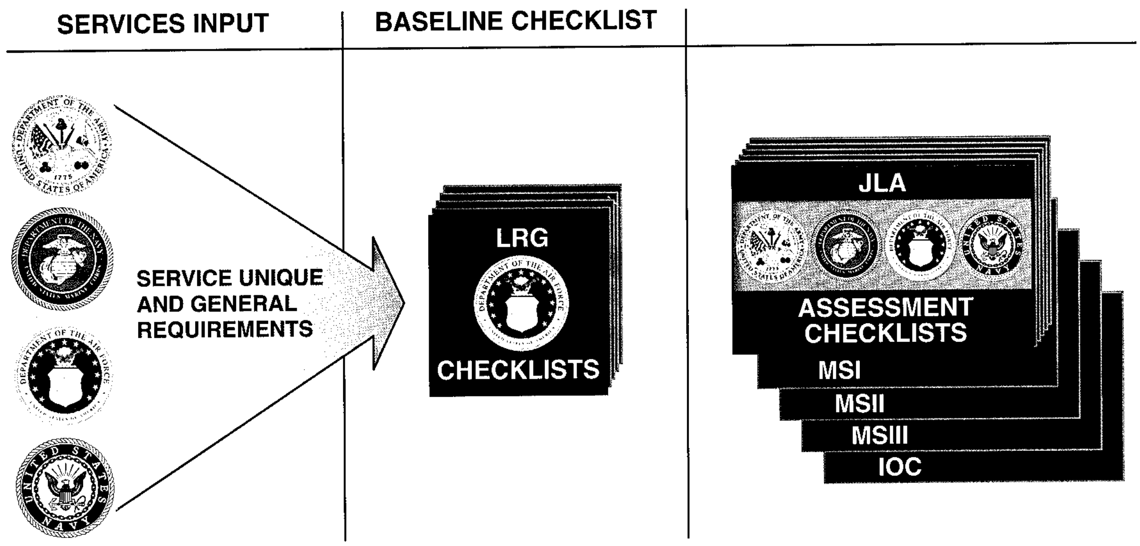
During 1993, a Joint UAV Logistics Management Team (JULMT), consisting of the UAV JPO, UAV Assistant Program Managers for Logistics, and a Defense Logistics Agency representative, was chartered by the PEO to provide oversight of JL-COE activities. MOAs are being executed again in 1994 for the JL-COE support of the JT UAV logistics program requirements and for UAV JPO joint logistics requirements.

7.1.4 UAV Family Depot Policy

The UAV depot maintenance strategy had its roots as a 1991 initiative by the Defense Depot Maintenance Council to streamline and strengthen depot maintenance activities. A coordinated, multi-Service committee chartered by the UAV JPO established a depot maintenance strategy for UAVs. The study team report recommended that the depot planning activities of the lead Service for UAV programs be directed toward the designation of a single Service activity as a family depot for all UAVs. Under the direction of the UAV JPO and guidance of the JULWG, and in coordination with the JT UAV program manager, depot maintenance planning are being initiated through the Joint Depot Maintenance Analysis Group.

7.1.5 Joint Logistics Assessment

In coordination with the Services, the UAV JPO proposed, developed, and validated a JLA initiative for UAVs. This initiative eliminates redundancy in the Services' logistics assessments while ensuring legitimate logistics requirements are adequately addressed. During the latter part of 1992, a JLAWG, consisting of representatives from the Services, was chartered through an MOA that established a joint ILS assessment process for UAVs. The JLAWG developed joint milestone checklists that incorporated each Service's assessment criteria and



LEGEND

IOC = Initial Operational Capability
JLA = Joint Logistics Assessment
LRG = Logistics Review Group

MSI = Milestone One
MSII = Milestone Two
MSIII = Milestone Three

Figure 7-2 JLA Milestone Checklist Development

offered the Services and the UAV JPO an economical, logical alternative to individual logistics assessments. Figure 7-2 shows the process of using the USN Logistics Review Group process as the baseline and shows how Service-unique questions and concerns were added to develop the JLA Milestone Checklist. The JLA process and procedures were validated in 1993 through a successful test case application to the Hunter UAV program (USA, USN, and USMC were participating Services). The JLA process was also used by the PEO of the Joint Direct Attack Munitions project to conduct a successful logistics assessment of the dual-Service (USAF and USN) program. The Joint Direct Attack Munitions application validated the use of the JLA process for joint programs. As a result of these achievements, the multi-Service, JLAWG recommended in 1993 that the JLA procedures be published as a PEO instruction to be used for logistics assessments of all UAV programs and also requested the PEO JLA instruction be distributed to all PEOs of joint programs for information and possible use.

7.1.6 Centralized PICA for UAVs

In 1993, the UAV JPO proposed the designation of a centralized PICA for UAVs. Assignment of a single PICA for newly introduced, unique UAV nonconsumables, regardless of the acquisition Service, provides effective inter-Service wholesale support and precludes future interim management duplication of multi-Service used UAV nonconsumables. The PICA initiative is being presented to the JULWG for evaluation during 1994.

7.1.7 UAV Family Configuration Management (CM)

A PEO(CU) instruction to define UAV family configuration management requirements was published in 1993. It describes the UAV family CM hierarchy and defines policies and procedures to provide for uniform CM across the UAV family of systems. The objective of the UAV family CM is to delineate a process for achieving and ensuring hardware/software C&I and the maintenance of JIIs. As an action agenda item for 1994, the UAV JPO is coordinating the kickoff

meeting of the UAV family Configuration Management Board.

7.1.8 UAV Logistics Lessons Learned Repository

Planning for a UAV logistics lessons learned repository was initiated in 1993. The purpose of the program is to gather and record experiences and lessons learned, both positive and negative, based on the total experience gained across the breadth of UAV acquisition programs. Understanding and applying sound business practices that have demonstrated successes or corrected problems in similar circumstances may not avoid or eliminate all program risks, but will reduce risks to an acceptable level. Establishment of the UAV lessons learned repository at the JL-COE is a 1994 goal. PEO(CU) plans to publish instructions that will establish policies and procedures to ensure access to and participation in the logistics lessons learned program by the UAV community.

7.1.9 UAV Logistics Management Guidance and Procedures

Near term focus is on establishing a viable link between logistics capabilities, functions, and processes. This linkage is being accomplished through the conduct of studies and analyses and the development and promulgation of guides documenting joint UAV ILS concepts and initiatives. The UAV logistics community is using these guides to structure and execute logistics programs in the multi-Service UAV environment. In 1994, continual assessment and refinement is being accomplished for core processes, metrics, and other related processes in order to foster a logistics orientation and climate within the UAV community so that sound concepts and practices can be implemented and accepted. The changes faced by the material acquisition community mandate more efficiency and effectiveness. Coordination with the Services through the JULMT, JULWG, and Aviation Logistics Board of the Joint Logistics Commanders ensures the proposed approaches are evaluated in terms of their utility to UAV programs and Service requirements. The following areas are being addressed in 1994:

- Publish a Joint Integrated Logistics Support Plan for Pointer Hand Launched UAV
- Standardize UAV readiness reporting and operational availability methodology
- Coordinate and publish a UAV family logistics support analysis (LSA) applications guide
- Coordinate and publish a UAV Capstone ILS Planning Guide
- Establish PEO policy for UAV family management codes
- Establish a joint continuous acquisition and life cycle support approach for UAVs.

7.1.10 Joint Logistics-Management Information System

The JL-MIS is a UAV JPO initiative begun in 1991 to provide UAV program offices with access to UAV-related logistics data. The JL-MIS is being developed to reflect continuous acquisition and life cycle support and corporate information management initiatives. This system will provide the capability to combine UAV logistics activities with UAV related data bases, such as integrated weapon system data bases, Contractor Integrated Technical Information Services, and Government Integrated Technical Information Service for rapid and integrated analysis to enhance logistics support and assessment. System planning allows this capability to support the program offices with information required to help determine system specifications, readiness levels, and supportability requirements. Maximum use of existing software programs within the Service logistics community is being made whenever the software can meet joint requirements.

In 1993 the development of the JL-MIS JLA module was completed. This initial module automates the process, provides an analytical tool, and shows a program's logistics status. The JLA module is being implemented on the PEO(CU) local area network and will be available to support the status of logistics assessments.

Continuing efforts from 1993 include coordination with the JLSC to develop and implement a Configuration Management Information System (CMIS) module to support analysis and interchange of engineering and technical data within the UAV community. The implementation of the CMIS module will greatly enhance the ability of the logistics and engineering community to perform comparisons among subsystems and identify C&I impacts. Goals for JL-MIS in 1994 are to:

- Provide JLA module operational support to the logistics and engineering user communities
- Develop and integrate the LSA and LSA record analysis modules into the JL-MIS
- Develop and integrate the CMIS module into JL-MIS

- Develop a JLA Administrator's Guide
- Develop a training plan and instructor's training materials for CMIS
- Publish a desktop reference users' guide for JL-MIS/CMIS
- Continue coordination with the JLSC to enable PEO(CU) to benefit from joint logistics standardization and commonality initiatives.

7.2 JOINT UAV TRAINING

Joint training planning for UAVs continues to reflect Congressional guidance to minimize personnel and training costs. Development of a Joint Training Management Plan is underway to promote standardization of training plan development and implementation of congressional guidance. Formal joint UAV training uses common core modules and common core training materials. The UAV Joint Service Training Center, Fort Huachuca, AZ supports training for Hunter UAVs. The USA has been designated as UAV JPO training agent for the JT UAV program.

The joint Service instructors and course developers from Joint Service Training Center work with the JT UAV contractors in development of the required system training. Unique Service training requirements are the responsibility of each participating Service. Contractor training commences in late 1994 to meet early fielding of the Hunter UAV. Government conducted follow-on training is scheduled to begin in late 1995.

During an annual training cycle, estimated maximum student capacity using operational hardware is limited to no more than 300 students on a 3-shift-per-day basis. It is estimated that after early 1997, student throughput will significantly exceed the training capacity. Therefore, the UAV JPO has initiated action with the Naval Air Warfare Center Training Systems Division, Orlando, FL to develop a training system that offsets operational hardware requirements and meets the projected throughput. The training system, when developed, will include a mix of classroom, interactive courseware, laboratory, and simulation study, team training, and experience with actual equipment. The UAV JPO goals for joint training in 1994 are to:

- Continue to coordinate the development of joint UAV training and use of "common core" training material in support of Hunter UAV training requirements
- Explore utilization of the Defense Information Systems Network for unit operational and maintenance training
- Provide guidance to satisfy UAV system peculiar training requirements
- Promulgate the Joint Training Management Plan
- Establish and promulgate the charter for a UAV Joint Management Training Team
- Develop and implement a training and monitoring assessment program
- Coordinate analysis, design, development, and acquisition planning of a Joint UAV training systems device simulator.

7.3 HUMAN SYSTEMS INTEGRATION (HSI)

In support of documentation requirements of DoD Directive 5000.1 and DoD Instruction 5000.2, each UAV program prepares both HSI Plans and Training Development Plans. Both plans address HSI impacts upon design and schedule. UAV programs follow USN and UAV JPO policy and guidance for development of these plans. Each UAV program identifies an individual responsible for HSI.

The HSI initiatives begun in the UAV programs are being continued and expanded. A man-machine interface risk reduction effort began in the first quarter of FY94 with an operator workload analysis of the Hunter GCS, followed by a crew performance evaluation using Hunter trained soldiers and marines to validate the accuracy of the task timelines and shift length. The results of the evaluation are being used to update the training program and system software to enhance the user-computer interface and reduce operator workload. The results are also being used to influence the design of the Maneuver Variant GCS. An interactive Maneuver Variant GCS man-machine interface configuration is being prototyped using lessons learned from Hunter, appropriate DoD standards, and users in the loop. A crew performance evaluation is to be conducted during the fourth quarter FY94 to validate operator workload and manpower requirements. These results are to be used in the development and will be provided to the Maneuver contractor as guidance for man-

machine interface development. These initiatives influence design and reduce risk throughout the acquisition cycle by identifying manpower, personnel, and training tradeoffs in connection with emerging LSA information. Other HSI tradeoffs include: cost, schedule, performance, and risk.

Existing skills are stressed to minimize unique requirements in the force structure. Training and training device requirements are continuously evaluated to minimize time and material resources, training aids, and facilities; to maximize modularity and embedded training; and to evaluate on-the-job training. Human factors, safety, and health hazard issues also receive similar analysis for optimization of the entire HSI program throughout the UAV program. Manpower Estimate Reports (MERs) completed and planned are applied to ensure that force structure is not unduly impacted.

Methodology and formats contained in Under Secretary of Defense for Personnel and Readiness guidance on MER preparation and a memo of 28 May 1991 are used to ensure reports from all Services are compatible. The UAV JPO point of contact for these requirements is the Director of Joint Logistics.

UAV program managers develop HSI plans after concept studies are approved. The program managers then document the management and resolution of HSI issues during the acquisition process. Human systems goals and objectives, constraints, tradeoffs, risks, and cost drivers documented in the plan serve as the basis for HSI reporting requirements in other acquisition program documentation. At a minimum, each plan satisfies program documentation requirements for each of the six HSI elements specified in DoD 5000.2, Part 7, Section B, Paragraph 3a(3). MERs are prepared by program managers to provide detailed manpower requirements information for UAV programs acquisition category (ACAT) ID as they approach MSII with updates provided at MSIII. In the case of joint UAV programs, the lead Service is responsible for the delivery of MER information for all Services involved in the program. There is one MER for each Service involved. Joint UAV programs also are prepared to explain cross-Service coordination that has occurred in the preparation of the MERs. UAV program managers use the MER to:

- Establish an accurate estimate of manpower requirements that must be maintained during peacetime to sustain readiness at a level that will ensure adequate wartime force capability
- Report the Service's ability to meet these manpower requirements under currently authorized manning levels and policies
  - Identify an increase in end-strength that will be required for full operational deployment of the program
  - Discuss how the system will be operationally deployed if no increases in military and civilian end strengths are authorized
- Identify any changes in system planning factors and manpower requirements reported at the previous milestone review
- Address the affordability of the system from a manpower perspective; establish a manpower requirements baseline to be used in projecting manpower costs for the new system over its life cycle.

ACRONYMS (Section 8)

DESA	Defense Evaluation Support Activity
DoD	Department of Defense
DT&E	Developmental Test and Evaluation
FAA	Federal Aviation Administration
ILS	Integrated Logistics Support
NGB	National Guard Bureau
OSD	Office of the Secretary of Defense
OTA	Operational Test Agency
OT&E	Operational Test and Evaluation
T&E	Test & Evaluation
TEMP	Test and Evaluation Master Plan
UAV	Unmanned Aerial Vehicle
UAV JPO	Unmanned Aerial Vehicle Joint Project Office
UGV	Unmanned Ground Vehicle
USA	United States Army
USN	United States Navy

8.1 OVERVIEW

The UAV JPO provides an interface for UAV developmental test and evaluation (DT&E) among the program management offices and supporting multi-Service field test activities that comprise the UAV Joint Test Force. The UAV JPO provides liaison to individual Service headquarters and OSD (Director, Test and Evaluation and Director, Operational Test and Evaluation) with regard to both DT&E and operational test and evaluation (OT&E) of UAV systems. Additionally, the UAV JPO provides liaison to the individual Service OT&E agencies for the planning and support of UAV operational testing. The UAV JPO maintains the status capabilities, limitations, policies, and procedures associated with national facilities, as well as the environments that are suitable for UAV test and evaluation activities. The respective Test and Evaluation Master Plans (TEMPs) for each of the UAV programs readily serve as a source for scope, objectives, structure, and resources of developmental and operational test programs.

8.2 DEVELOPMENTAL TESTING

Individual program managers are responsible for the overall DT&E programs conducted by participating field test activities and respective contractors. Government test ranges possessing adequate restricted airspace, terrain, and sea areas to support UAV DT&E are limited in number and are generally located in the western United States. As with most test facilities, projected workloads may require prioritization of test projects and early scheduling of DT&E programs. Accomplishment of UAV DT&E requirements necessitates the resourcing and scheduling of DT&E activities among the multi-Service test facilities without any significant investment in improvements to the various facilities (see Table 8-1). A UAV avionics T&E handbook is under development that will provide guidance on payload, data link, and ground control station testing. Also, a test and evaluation data base is under development that will provide lessons learned.

UAV \ Site	NAWCAD Patuxent River, MD	NAWCAD China Lake, CA	NAWCAD Point Mugu, CA	Hill AFB/ Dugway, UT	Yuma Proving Ground, AZ	Ft. Huachuca, AZ	Redstone Arsenal, AL	White Sands Missile Range, NM	Defense Evaluation Support Agency, NM	Fort Sill, OK	NSWC Dahlgren, VA	NAWCAD Trenton, NJ
Hunter		Survivability				FQ&P and sensor, LUT + OA	Sensor captive carry & SIL	Environmental & Transportability				Propulsion
Maneuver Variant					AV sensor demo before RFP release							
Shipboard Variant			LHD land based test									
Pioneer			FQ&P			Op/maint training						
MAE					FQ&P and sensor	FQ&P and sensor						
Pointer Hand Launched		Accept test, GPS/auto-nav develop					UGV demo		Payload development			
EXDRONE	FQ&P and payload develop/integ			GPS/auto-nav develop								
MAVUS										FQ&P and autoland development	Data link	
TRUS					FQ&P							
VLAR					FQ&P							
Medium Range	Mini-carrier suitability	MARS		FQ&P and sensor								Propulsion

LEGEND

FQ&P = Flying Qualities and Performance
GPS = Global Positioning System
LHD = Landing Helicopter-Dock Ship
LUT = Limited User Test
MARS = Mid Air Retrieval System
OA = Operational Assessment
RFP = Request For Proposal
SIL = System Integration Laboratory
UGV = Unmanned Ground Vehicle

Table 8-1 DT/OT Test Sites

8.3 OPERATIONAL TESTING

The USN Operational Test and Evaluation Force is designated as the lead OT&E agency for all UAV operational testing. A principal Operational Test Agency (OTA) can be delegated the lead OTA responsible for planning, coordinating, scheduling, conducting, and reporting on an individual program's operational testing. At this time, the USA Operational Evaluation Command has been designated the principal OTA for conducting the Hunter UAV system operational testing.

Through the system integration of numerous technologies in their development, the capabilities and overall operational effectiveness of respective UAV systems are just being recognized. As such, the multi-Service user community has been actively involved in the development of doctrine and organizational guidance for the employment of UAV systems throughout the spectrum of threat scenarios confronting our forces. These doctrines and concepts must include a suitably trained force structure. Appropriately trained Service personnel are integral to the planning and execution of formal OT&E that will be needed to support overall program milestones.

Adequate OT&E entails portraying operational test realism. This requires test sites possessing representative topographical and climatic environments of areas where the UAV system could be deployed. This also requires the integration of interfacing and supporting units, as well as threat forces depicting complex target arrays. Accordingly, formal operational testing for UAV systems will require substantial resourcing in personnel, material, and test sites.

ILS for UAV systems is evolving and will require definition and maturity to support formal OT&E. Respective ILS plans for each of the UAV systems are an integral part of both developmental and operational test planning and execution. The ILS plans will be employed to ensure early identification and optimization of critical logistic elements. Generally, logistics support for acquisition programs is not mature during DT&E and OT&E. However, logistic support must be sufficiently developed to allow operational personnel to perform organizational-level maintenance during OT&E.

8.4 UAV CAPSTONE MASTER TEST PLAN

The UAV Capstone Master Test Plan, now in final draft, addresses the total UAV joint test program in general terms. It is an over-arching document that integrates broad test objectives, identifies general responsibilities, and identifies generic test resources. It addresses test support responsibilities, test sites and instrumentation, threat systems, modeling and simulation, testbeds, manpower and training requirements, and safety and environmental considerations. Together with the UAV system TEMPs, they constitute a broad plan relating test objectives to required operational and critical technical characteristics.

8.5 SURVIVABILITY TESTING

The predicted survivability of a UAV system in a combat environment is a critical factor that must be quantified in a cost-effective manner. Using nondestructive field tests, vulnerability and susceptibility can be determined to a reasonable level of confidence using computer simulations incorporating force-on-force models. Operational training exercises also hold potential for determining UAV survivability at reasonable cost.

To accurately predict UAV system survivability in an operational environment, representative user personnel will perform mission planning to determine the best solution comprising both mission accomplishment and system survivability. To assure that only certified computer models are employed in the analysis of operational UAV survivability, the services of the Survivability/Vulnerability Information and Analysis Center, a DoD technical information center with acknowledged expertise in aircraft survivability, is used.

8.6 DEFENSE EVALUATION SUPPORT ACTIVITY UAV EFFORTS

The UAV JPO has established a memorandum of understanding with DESA, Kirtland Air Force Base, NM to conduct joint UAV operations and systems evaluation efforts. DESA is an OSD activity, reporting to the Director, Test and Evaluation, that is chartered to provide a broad spectrum of test and evaluation support to both DoD and non-DoD agencies. Primary objectives and goals concerning DESA support to the UAV JPO are to:

- Develop an operations and technical maintenance capability to support UAV systems' demonstrations and evaluations

- Develop a test and evaluation strategy and use of DESA's test and evaluation capability and association with multiple government agencies (both DoD and non-DoD) to conduct timely evaluations of UAV systems and associated sensors for DoD and non-DoD mission applications

- Provide a cost-effective UAV support capability geared towards rapid evaluation of UAV

systems and associated equipment.

During the past year, DESA provided or supported operational demonstrations of UAV capabilities using the Pointer Hand Launched UAV for various government and nongovernment activities. In particular, a UAV evaluation effort has been established with the NGB to evaluate UAV applications in both federal and state National Guard mission areas. The Oregon National Guard used the Pointer Hand Launched UAV to evaluate operational counterdrug and other law enforcement missions. DESA also supported a technical interoperability evaluation between the Pointer UAV and a UGV at Redstone Arsenal, AL. Pointer was also used to observe prehistoric Native American ruins in New Mexico in support of a Bureau of Land Management effort to possibly use UAVs to capture poachers of national treasures.

Additionally, DESA is working with local, regional, and national FAA elements to address airspace management and safety certification processes for UAV operations in both military and civilian applications.

ACRONYMS (Section 9)

CARS	Common Automated Recovery System
C&I	Commonality & Interoperability
DEA	Data Exchange Agreement
DoD	Department of Defense
FAA	Federal Aviation Administration
FCT	Foreign Comparative Testing
FMS	Foreign Military Sales
FY	Fiscal Year
MAVUS	Maritime VTOL UAV System
NATO	North Atlantic Treaty Organization
NNAG	NATO Naval Armaments Group
SEEP	Scientist and Engineer Exchange Program
TTSARB	Technology Transfer and Security Assistance Review Board
UAV	Unmanned Aerial Vehicle
UAV JPO	Unmanned Aerial Vehicle Joint Project Office
US	United States
USN	United States Navy
ZEOP	Z-Electro-Optical Payload

9.1 INTERNATIONAL PROGRAM OVERVIEW

The UAV JPO is the focal point for all UAV foreign and international programs. The UAV JPO recommends policy and provides guidance for the development of international UAV program operations, planning for and implementing a consolidated joint management structure to coordinate international and foreign military sales (FMS) efforts for participating Services and fostering defense cooperation with allied countries. Figure 9-1 indicates the wide range of international activities carried out by the UAV JPO.

9.2 DEFENSE COOPERATION

Defense cooperation is a major area of focus for the UAV JPO. Some of the prime advantages of international cooperation are promoting the more efficient use of scarce defense resources, aiding industrial modernization, reducing research and development costs, improving access to emerging technology, and strengthening US/allied defense relationships. UAV JPO cooperative initiatives are being focused in the areas of Data Exchange Agreements (DEAs), Scientist and Engineer Exchange Programs (SEEPs), cooperative agreements, NATO Working Groups on UAVs (PG/35), and FCT.

Primary goals of the UAV JPO DEA initiatives are to provide a means for the direct exchange of data on national UAV programs. The DEA agreement sets out priorities and provides the vehicle for the exchange of technical and program data on a quid pro quo basis. DEA conferences provide the opportunity for one on one briefings on national UAV programs. The briefings are followed by working sessions to plan the means to capitalize on each of the UAV initiatives to reduce costs, preclude duplication, and improve interoperability and standardization. The DEAs serve as a catalyst to marshal DoD and friendly nations' technological capabilities. DEAs serve as the vehicle for the exchange of scientific and technical data and information on a quid pro quo basis. DEAs have been approved for Israel, Germany, South Korea, and the Netherlands, and are being developed with Canada, the United Kingdom, and France. In Figure 9-2, US and German officers view Pointer Hand Launched UAV flight demonstrations during the first US/German DEA exchange meeting. The development of DEAs is anticipated with other friendly nations where mutually benefi-

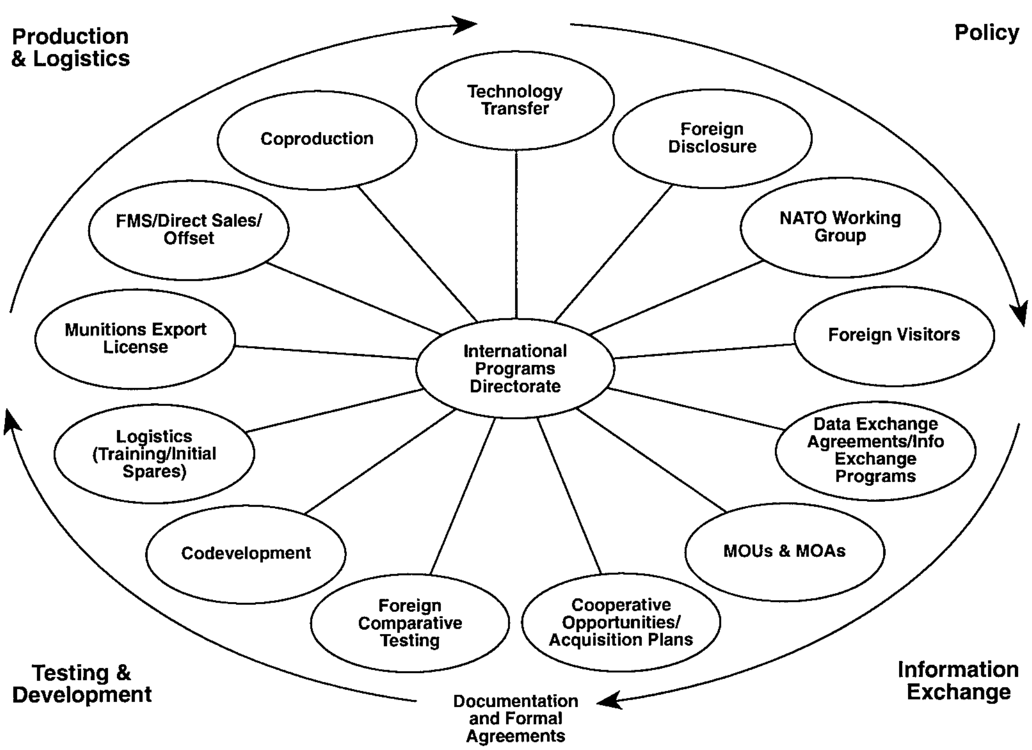


Figure 9-1 International Activities of the UAV JPO

cial opportunities exist for data and information exchange on UAVs.

The SEEP is a useful bilateral personnel exchange program that offers additional opportunities for defense cooperation with friendly nations. The first UAV SEEP was recently concluded with the German government. This exchange resulted in the assignment of a highly qualified German engineer from the German Ministry of Defense to the USN UAV program office for one year. During his assignment he assisted in the drafting of specifications for the maritime UAV program. He then returned to an assignment as a program manager for the German maritime UAV program. The UAV JPO is pursuing SEEP opportunities with the United Kingdom, Canada, and the Netherlands as an important means to build a foundation for future cooperation.

A Defense Development Sharing Agreement between the US and Canada has been approved for a second phase of the development, test, and evaluation of the MAVUS II. The US will benefit from shared funding with Canada of a proven test vehicle, the Canadair CL-227, incorporating the US developed CARS for land/sea based flight testing. MAVUS II is scheduled for at-sea employment on the USS Vandegrift (FFG-48) during the spring of 1994. See Section 3 for further discussion of MAVUS II.

The UAV JPO continues an active role in NATO through representation as Chairman of NATO Naval Armaments Group (NNAG) PG/35 on Maritime UAVs. The NATO forum has been used extensively to demonstrate leading US technology, to obtain financial assistance for UAV initiatives, and to prepare the future for interoperable maritime UAV systems. To date a NATO Staff Requirement has been prepared, and feasibility studies and operational demonstrations of UAV systems have been conducted. Ongoing UAV JPO initiatives conducted through NATO include:

- The introduction of an interoperability plan to achieve successive levels of UAV interoperability among the NATO navies. The plan provides the means to establish remote reception of UAV video down link among NATO ships providing an important new capability for peacekeeping and crisis management operations. The first phase of the interoperability plan now underway also includes the cooperative update of key NATO Standardization Agreements including Allied Tactical Publications to ensure a smooth operational transition as maritime UAVs are introduced by more navies in the near future

- Development of a risk reduction plan providing a specific list of the technical trades required to be resolved to acquire a cost-effective system. To date over 30 UAV development related initiatives collectively funded by the members of NNAG PG/35 have been cataloged in the risk reduction plan (representing a total value in US currency of over 40 million dollars in the last 3 years). The plan has allowed the participants to coordinate initiatives to avoid redundancy and financially leverage national programs based on the shared results of the funded activities

- Establishment of a joint working group with the Council for European Airspace Coordination on maritime UAV airspace management to define the way ahead for flight coordination of UAVs. The UAV JPO ensures a close coordination with the FAA advisory committee on UAV airspace management to ensure the latest US initiatives are reflected in the rules and regulations which will be updated for operations in the European theater. The group will

Figure 9-2 US and German Officers View Pointer Flight Demonstrations

conclude the way ahead document in December 1994 for action by Council for European Airspace Coordination national aviation authorities

- Establish inroads for joint NATO service applications of UAVs through the NATO Air Force Armaments Group Air Group IV, Information Exchange Group 5 on above water warfare, the Military Agency for Standardization Naval Board, and the Tactical Air Working Party. The UAV JPO provides inputs to each of these groups through representation in PG/35 to focus efforts on the improved prospects for interoperability of UAVs.

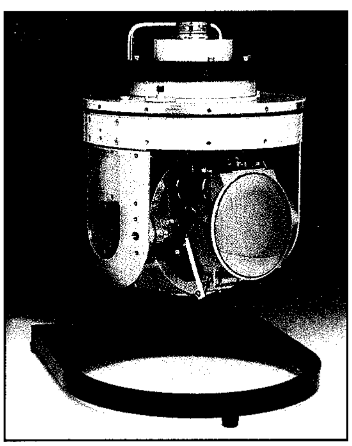


Figure 9-3
Israeli ZEOP FLIR/TV Sensor Pod

The UAV JPO uses the FCT program as a conduit for defense cooperation to maximize scarce personnel and fiscal resources. Although the program operates on a relatively small budget and supports all military departments, the UAV JPO enjoys a fairly good track record in competing for those funds. In fact, the Israeli-produced ZEOP (see Figure 9-3), a small, lightweight, stabilized electro-optical sensor for UAVs, has been approved and funded by DoD under the FCT program. In addition, the UAV JPO is currently evaluating several potential systems and subsystems to determine which might best meet the FCT candidate nomination criteria and should be recommended for FY95 funding.

9.3 INTERNATIONAL SALES

A primary goal of the UAV JPO international efforts is to conduct briefings on the advantages of US-developed UAVs to interested foreign countries. Potential international sales of UAVs (FMS or commercial) offer significant advantages to both the US and the purchasing country. These advantages include creating economies of scale (larger production runs), preserving production lines (DoD mobilization base), and making a direct and positive impact on the US domestic economy (preservation of US employment base and generation of US exports). In addition, both DoD and the purchasing country would gain benefits from shared C&I with allied country UAVs. Opportunities for joint combined operations and training are also enhanced when foreign UAV operators share US-developed equipment, procedures, and training.

A consistent, well coordinated foreign disclosure policy for UAV technology transfers to foreign nations enables US UAV defense contractors to effectively target their marketing efforts toward those countries in which export approval is most likely. A significant step in this effort was reached when the UAV Technology Transfer and Security Assistance Review Board (TTSARB) Decision Memorandum was approved in late 1993. The USN UAV TTSARB Decision Memorandum provides the broad policy basis for UAVs and payloads being considered for sale to friendly countries and is the guideline for the export license application review process. A TTSARB foreign disclosure policy relating to the releasability of targets and their associated technologies is currently in the development phase.

Briefings are effective tools to improve the understanding of key members of the US and international community on the numerous advantages of defense cooperation and FMS programs for UAVs. The UAV JPO has initiated a series of briefings for Unified Command staff members and security assistance officers/defense attaches on UAV programmatic status. The perspective and assistance of these organizations will provide the UAV JPO with vital information on projected/potential UAV sales in their respective regions. It is anticipated that worldwide interest in UAVs will generate significant commercial and military sales in the foreseeable future.

ACRONYMS (Section 10)

ACTD	Advanced Concept and Technology Demonstration
DARO	Defense Airborne Reconnaissance Office
FY	Fiscal Year
MAE	Medium Altitude Endurance
OSD	Office of the Secretary of Defense
PE	Program Element
RDT&E	Research, Development, Test and Evaluation
UAV	Unmanned Aerial Vehicle
UAV JPO	Unmanned Aerial Vehicle Joint Project Office

The OSD fiscal resource sponsor for UAV systems is the DARO. Funds execution is accomplished by the UAV JPO.

10.1 RDT&E

UAV RDT&E is programmed and budgeted in OSD PE 0305154D. These funds support systems, component, and RDT&E development while ensuring commonality and interoperability. The UAV JPO is tasked to execute the MAE UAV ACTD.

10.2 PROCUREMENT

Procurement is programmed and budgeted in OSD PE 0305154D P1 line item 4003, Defense Wide Procurement, UAV.

10.3 OTHER

Operations and maintenance, military personnel, and military construction are individually programmed and budgeted by the Services.

10.4 FUNDING (IN OSD PE 0305154D)

See Table 10-1.

	FY94	FY95	FY96 - FY99
RDT&E ($M)			
• Tactical UAVs	85.2	132.4	179.2
• MAE	40.0	42.1	72.0
Procurement ($M)	88.3	250.7	1,095.6

Table 10-1 UAV Funding

ACRONYMS (Appendix A)

ACAT	Acquisition Category
COEA	Cost and Operational Effectiveness Analysis
CR	Close Range
DoD	Department of Defense
EW	Electronic Warfare
FLOT	Forward Line of Own Troops
HAE	High Altitude Endurance
JROC	Joint Requirements Oversight Council
JT UAV	Joint Tactical UAV
MAE	Medium Altitude Endurance
MAGTF	Marine Air-Ground Task Force
MNS	Mission Need Statement
MR	Medium Range
ORD	Operational Requirements Document
RSTA	Reconnaissance, Surveillance and Target Acquisition
SR	Short Range
UAV	Unmanned Aerial Vehicle
USA	United States Army
USD(A)	Under Secretary of Defense (Acquisition)
USMC	United States Marine Corps
USN	United States Navy

This Appendix provides the rationale for the need for UAVs by DoD. Mission and operational requirements are addressed.

A.1 MISSION NEED STATEMENTS

The Chairman of the JROC has validated MNSs for UAV capabilities in the DoD. These need statements characterize UAVs in four operational envelope categories: close, short, medium, and endurance range. There are now only two classes of UAVs, Tactical and Endurance. Table A-1 provides a summary of UAV MNS required capabilities.

A.2 CATEGORIES OF CAPABILITIES

As stated in Table A-1, the Joint Tactical UAV Program addresses the requirements of the CR and SR MNS, while the MAE and HAE address the requirements of the endurance MNS.

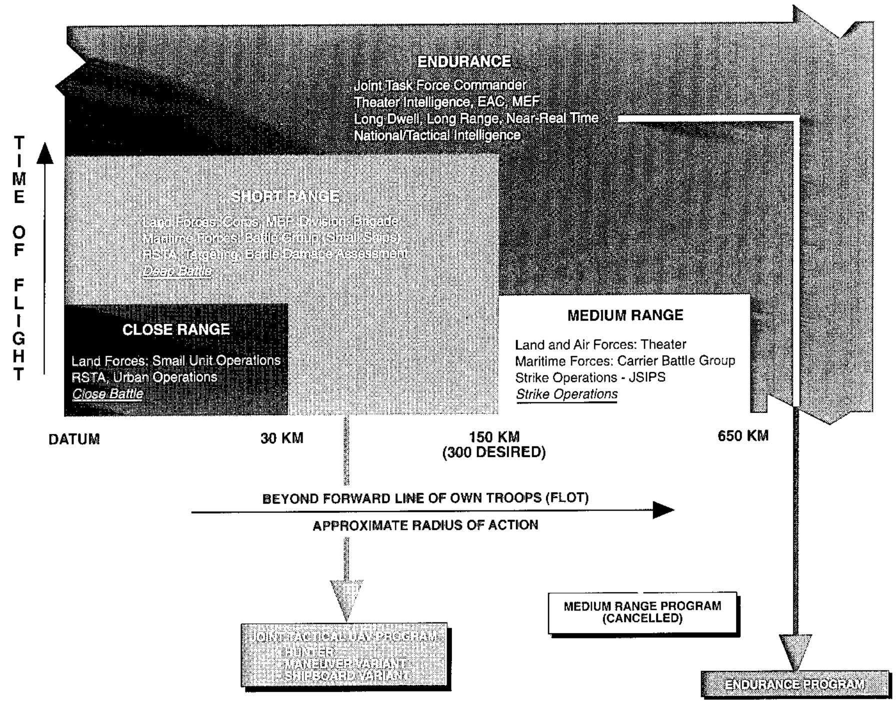
The JT UAV Program, discussed in detail in Section 3, addresses the requirements of the SR and CR MNS (see Figure A-1). The Hunter UAV supports the needs of USA divisions through echelons above corps level and of MAGTF through the Marine Expeditionary Force level. The Shipboard Variant of the Hunter UAV supports USN combatant needs. Enemy activities out to a range of 150 kilometers or more beyond the FLOT or datum point (in USN operations) can be exploited for 16 hours of every 24 hours with the Hunter UAV system. A Maneuver Variant of the Hunter UAV addresses the needs of lower-level units such as USA light divisions/brigades/battalions and USMC regiments/battalions to target their direct support weapons systems and to conduct RSTA out to approximately 30 kilometers beyond the FLOT.

	JOINT TACTICAL PROGRAM			ENDURANCE PROGRAM
CATEGORIES / CAPABILITIES	CLOSE	SHORT	MEDIUM	ENDURANCE
OPERATIONAL NEEDS	RS, TA, TS, EW, NBC MET	RS, TA, TS, MET, NBC, C^2, EW	PRE- AND POST-STRIKE RECONNAISSANCE, TA	RS, TA, C^2, MET NBC, SIGINT, EW, SPECIAL OPS
LAUNCH AND RECOVERY	LAND/SHIPBOARD	LAND/SHIPBOARD	AIR/LAND	NOT SPECIFIED
RADIUS OF ACTION	NONE STATED	150 KM BEYOND FORWARD LINE OF OWN TROOPS (FLOT)	650 KM	TBD
SPEED	NOT SPECIFIED	DASH> 110 KNOTS CRUISE< 90 KNOTS	550 KNOTS <20,000 FT .9 MACH >20,000 FT	NOT SPECIFIED
ENDURANCE	24-HRS CONTINUOUS COVERAGE	8 TO 12 HRS	2 HRS	≥ 24 HRS ON STATION
INFORMATION TIMELINESS	NEAR-REAL-TIME	NEAR-REAL-TIME	NEAR-REAL-TIME/ RECORDED	NEAR-REAL-TIME
SENSOR TYPE	DAY/NIGHT IMAGING, EW, NBC	DAY/NIGHT IMAGING, DATA RELAY, COMM RELAY, RADAR, SIGINT, MET, MASINT, TD, EW	DAY/NIGHT IMAGING, SIGINT, MET, EW	SIGINT, MET, COMM RELAY, DATA RELAY, NBC, IMAGING, MASINT, EW
AIR VEHICLE CONTROL	NONE STATED	PRE-PROGRAMMED/ REMOTE	PRE-PROGRAMMED	PRE-PROGRAMMED/ REMOTE
GROUND STATION	VEHICLE & SHIP	VEHICLE & SHIP	JSIPS (PROCESSING)	VEHICLE & SHIP
DATALINK	WORLDWIDE PEACETIME USAGE, ANTI-JAM CAPABILITY	WORLDWIDE PEACETIME USAGE, ANTI-JAM CAPABILITY	JSIPS INTEROPERABLE WORLDWIDE PEACETIME USAGE, ANTI-JAM CAPABILITY	WORLDWIDE PEACETIME USAGE, ANTI-JAM CAPABILITY
CREW SIZE	MINIMUM	MINIMUM	MINIMUM	MINIMUM
SERVICE NEED/ REQUIREMENT	USA, USN, USMC	USA, USN, USMC	USN, USAF, USMC	USA, USN, USMC, USAF

LEGEND

C^2 = Command and Control
EW = Electronic Warfare
JSIPS = Joint Service Imagery Processing System
MASINT = Measurements and Signatures Intelligence
MET = Meteorology
NBC = Nuclear, Biological and Chemical
RS = Reconnaissance and Surveillance
SIGINT = Signals Intelligence
TA = Target Acquisition
TS = Target Spotting
TD = Target Designator

Table A-1 MNS Summary



LEGEND
ATARS = Advanced Tactical Air Reconnaissance System
EAC = Echelon Above Corps
JSIPS = Joint Service Imagery Processing System
MEF = Marine Expeditionary Force
RSTA = Reconnaissance, Surveillance, and Target Acquisition

Figure A-1 Categories of Capabilities

The MR MNS addresses capabilities to provide pre- and post-strike reconnaissance of heavily defended targets and to augment manned reconnaissance platforms or high-altitude UAVs by providing high-quality, near-real-time imagery. These capabilities are different from those of most other UAVs in that the vehicle must fly at high subsonic speeds and spend relatively short amounts of time over target areas of interest. The MR UAV Program was established to address the requirements of the MR need statement. However, this program was recently terminated on 29 October 1993 by USD(A) for reasons of affordability and priority within the UAV family. There are no current plans to replace this program.

The Endurance MNS addresses a wide variety of missions and payload types. Required capabilities include imagery, signals intelligence, communications and data relay, EW, and others. Endurance UAV systems must have the capability to remain on station for 24 hours or more. Autonomous flight is required and data relay through satellites is greatly desired.

A.3 OPERATIONAL REQUIREMENT DOCUMENTS

A summary matrix of the ACAT I Major Defense Acquisition UAV Program ORDs that expand upon and refine the MNS baselines is provided in Table A-2. Only unclassified information is addressed. At present, the CR ORD is in staffing by the USN. The USA has approved the ORD and USN approval is deferred until completion of the COEA. The SR ORD has been approved.

CATEGORIES / CAPABILITIES	CLOSE RANGE*	SHORT RANGE**
SERVICE	USA, USN, USMC	USA, USN, USMC
SERVICE ORGANIZATIONAL LEVEL	DIV, BDE (USA) BN & LOWER	CORPS, EAC, DIV (USA) RPV COMPANY (USMC) SHIP (USN)
MISSION	RSTA	RSTA
RADIUS OF ACTION	50 KM (30NM)	CLASSIFIED
PAYLOAD CAPACITY	50 LBS	200 LBS
SENSOR	IMAGERY, MET	IMAGERY ECM
GROWTH	EW, NBC	SIGINT, MET, COMM
ENDURANCE	3 HRS	CLASSIFIED
LAUNCH/RECOVERY	STOL	CTOL
GROUND STATION	VEHICLE	VEHICLE
TOGW	TWO PERSON TRANSPORTABLE/ 200 LB CLASS	1,700 LBS
AIR SPEED	80 KTS	CRUISE < 90 KTS DASH > 110 KTS
ALTITUDE	10,000 FT	15,000 FT
DATALINK	ANTI-JAM CAPABILITY	ANTI-JAM CAPABILITY

* SATISFIED BY THE MANEUVER VARIANT UAV
** SATISFIED BY THE HUNTER UAV

LEGEND
BDE = Brigade
BN = Battalion
COMM = Communications
CTOL = Conventional Takeoff and Landing
DIV = Division
EAC = Echelon Above Corps
ECM = Electronic Countermeasures
EW = Electronic Warfare
MET = Meteorological
NBC = Nuclear, Biological, Chemical
RPV = Remotely Piloted Vehicle
RSTA = Reconnaissance, Surveillance, and Target Acquisition
SIGINT = Signals Intelligence
STOL = Short Takeoff and Landing
TOGW = Takeoff Gross Weight

Table A-2 ORDs Summary

This Appendix provides a tabular listing of the characteristics and capabilities of UAVs.

B.1 HUNTER/SHIPBOARD VARIANT UAV CHARACTERISTICS

Length/width	22.6 ft long/29.1 ft wingspan (6.9 m/8.9 m)
Weight	1,546 lbs (702 kg)
Cruise speed	> 90 kts (> 167 kph) with Dash Capability
Payload capacity	165 lbs (75 kg)
Mission endurance on station	8-12 hours
Max. radius of action	108 nm (200 km)
Max. altitude (ceiling)	15,000 ft (4,573 m)
Payloads	Day/night imagery plus relay
Launch/recovery	Unimproved areas (200m x 75m) Deck recovery assisted gear for Shipboard
Ground control station	Operate other air vehicles

Table B-1 Hunter/Shipboard Variant UAV Characteristics

B.2 MANEUVER VARIANT UAV CHARACTERISTICS

Mission endurance	3-4 hours
Max. radius of action	27 nm (50 km)
Max. altitude (ceiling)	10,000 ft (3,048 m)
Payload capacity	50 lbs (23 kg)
Minimum speed	≤ 75 knots
Payloads	Day/night passive imagery
Mobility	C-130/141 drive on/drive off/helo lift baseline on 2 HMMWVS and trailer
Launch/recovery	30 m by 75 m launch/recovery area with 10 m obstacle
Ground control station	Interoperable with Hunter UAV GCS/MPS

Table B-2 Maneuver Variant UAV Characteristics

B.3 PIONEER UAV CHARACTERISTICS

Length/width	14 ft long/17 ft wingspan (4.26 m/5.18 m)
Weight	450 lbs (204 kg)
Cruise speed	60 to 70 kts (97 to 113 kph)
Dash speed	100 kts (185 kph)
Mission endurance	≤ 5 hours
Payload capacity	65-100 lbs (29-45 kg)
Max. range	< 130 nm (239 km)
Max. altitude (ceiling)	< 15,000 ft (4,572 m)
Payload (current)	Real-time day & IR video, radio relay

Table B-3 Pioneer UAV Characteristics

B.4 MAE UAV CHARACTERISTICS

Mission endurance	24 hours of continuous coverage @ 500 nm
Max. radius of action	500 nm (922 km)
Max. altitude (ceiling)	3,000 ft to 25,000 ft (915 m to 7,620 m)
Payload capacity	450 lbs (204 kg)
Payloads	EO/IR package capable of > IIRS 6, SAR package capable of (classified) IPR
Datalink	UHF/Ku-band SATCOM and LOS DL for takeoff and landing
Mobility	C-130/141 transportable Operational within 6 hours of arrival
Launch/recovery	Land launch and recovery
Ground control station	Joint Tactical UAV System compatible

Table B-4 MAE UAV Characteristics

B.5 POINTER HAND LAUNCHED UAV CHARACTERISTICS

Length/width	6 ft long/9 ft wingspan (2.7 m/1.8 m)
Takeoff weight (w/payload)	8.5 lbs (3.9 kg)
Speed	19 to 44 kts (35 to 80 kph)
Mission endurance	1.0+ hour ($LiSO_2$ batteries) 20+ minutes (NiCd batteries)
Max. range (data link limit)	2.7 nm (5 km)
Payload weight	2.0 lbs (0.9 kg)
Payload	Color camera B&W low-light-level camera
Datalinks	RF uplink: VHF band RF downlink: microwave band
Data display	1 color monitor/1 B&W monitor
Navigation	Electric compass heading sensor GPS/autonavigation
Propulsion	300-watt samarium cobalt electric motor Folding pusher prop
Stabilization system	Self-stabilizing w/gyro stability system
Launch	Hand launch
Recovery	Deep stall/autoland

Table B-5 Pointer Hand Launched UAV Characteristics

B.6 EXDRONE UAV CHARACTERISTICS

Length/width	5.33 ft long/8.25 ft wingspan (1.6 m/2.5 m)
Weight	89 lbs (40 kg)
Speed	100 mph (162 kph)
Mission endurance	2.5 hours
Coverage per 12 hour period	6+ hours
Max. altitude (ceiling)	10,000 ft (3,048)
Payload capacity	25 lbs (11.4 kg)
Payloads	Down-looking zoom color camera (570 lines of resolution) EW communications jammer Down-look image intensifier
Payloads in development	Pan/tilt/zoom camera TRSS airborne relay FLIR
Navigation	GPS
Stabilization	Gyro stabilization system w/auto wing levelling
Datalinks	UHF uplink, microwave downlink
Data display	Color monitor
Ground Control Station	Interoperable w/IAS and any system w/RS170
Mobility	Roll on/roll off C130 and 2 HMMWVs w/trailer

Table B-6 EXDRONE Characteristics

B.7 VTOL UAV OPERATIONAL REQUIREMENTS

Radius of Action (Operating Station)	TBD
Speed	Achieve Station < 60 min (135 kts Cruise, 150 kts Dash)
Loiter	5.0 hours on Station @ 110 kts
Altitude	10,000 ft (3,048 M)
Sensor Type	ECM, Day/Night Imagery
Take Off and Landing	VTOL From/To Ship Helo Spot Autoland
Datalink	Ship Topside Compatible
Interoperability	USA, USMC Joint Tactical UAV

Table B-7 VTOL UAV Operational Requirements

B.8 MAVUS II CHARACTERISTICS

Takeoff weight	418 lbs (190 kg)
Speed	Hover to 70 kts (0 to 130 kph)
Mission endurance	2.5 hours
Max. radius of action	32 nm (59 km)
Max. altitude (ceiling)	10,000 ft (3,048 m)
Coverage	360 degrees
Payloads	FLIR, DTV, comm relay, EW
IFF	Mode 3
Collision avoidance	Strobe light
Max. wind	30 kts (55.5 kph)
Temperature	14 to 95 degrees
Rain	0.25 inches/hr
Visibility	0.25 nm (0.40 km)

Table B-8 MAVUS II Characteristics

B.9 TRUS CHARACTERISTICS

Takeoff weight	1,800 lbs (815 kg)
Speed	Hover to 150 kts (0 to 278 kph)
Mission endurance	Greater than 2.0 hours
Max. radius of action	110 nm (204 km)
Max. altitude (ceiling)	10,000 ft (3,048 m)
Payload capacity	30 lbs (16.4 kg)
Payloads	C-band beacon, flight termination system, flight instrumentation telemetry package
Recovery footprint	36 ft by 36 ft (11 m by 11 m)

Table B-9 TRUS Characteristics

B.10 VLAR REQUIREMENTS AND OBJECTIVES

Requirements	
VTOL	Unassisted vertical takeoff and landing
Controlled Hover	Minimum of 3 min in zero kt wind
Maximum TOGW	4,500 lbs (2,040 kg)
Objectives	
Payload	200 lbs (90 kg)
Endurance	5 hrs
Service Ceiling	10,000 ft (3,048 m)
Speed	150 kts

Table B-10 VLAR Requirements and Objectives

B.11 AMGSS CHARACTERISTICS

VTOL	Vertical takeoff and landing
Hover	Controlled hover capability
Range	25 miles (15.5 km)
Endurance per flight mission	Less than 30 min
Endurance for ground mission	Over a 24-hr period
Technology	Ducted fan or similar for personal safety
Launch/Recovery	Automatic control
Engine for platform	Function through entire flights & ground period
Transportable	By HMMWV

Table B-11 AMGSS Characteristics

B.12 WTS-34 AND WTS-117 ENGINE PERFORMANCE CHARACTERISTICS

Characteristics	WTS-34	WTS-117
Horsepower	51 hp	120 hp
Weight	60.5 lbs (27.4kg)	70.2 lbs (31.8kg)
BSFC (@ max power)	1.0 lb/hp-hr	.812 lb/hp-hr
Endurance	Less than 3 hrs	At least 3 hrs
MTBF	Baseline	higher
Life Cycle Cost	Baseline	lower

Table B-12 WTS-34 and WTS-117 Engine Performance Characteristics

B.13 500 WATT APU CHARACTERISTICS

Power	500 watts
Weight	< 29 lbs (< 13.2 kg)
Size	< 2 cubic feet
Fuel	JP5, JP8, diesel
Voltage	28 volts DC
Noise	< 70 dBA @ 7 meters
Reliability	500 hours MTBF
Duty cycle	24-hr continuous operation

Table B-13 500 Watt APU Characteristics

B.14 POWERPAK APU PERFORMANCE GOALS

Power	15 kw
Weight	300 lb (136 kg)
Size	12 cubic feet
Fuel	JP4, JP5, JP8, diesel
Voltage	60-Hz, 3-phase, 120/208 vac; 28 vdc
Noise	< 70 dBA @ 7 meters
Engine	Rotary, liquid cooled

Table B-14 PowerPak APU Performance Goals

ACRONYMS (Appendix C)

ATC	Air Traffic Control
AUVS	Association for Unmanned Vehicle Systems
C^3	Command, Control, and Communications
COEA	Cost and Operational Effectiveness Analysis
DEA	Drug Enforcement Agency
DESA	Defense Evaluation Support Activity
DoD	Department of Defense
DOE	Department of Energy
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FBI	Federal Bureau of Investigation
FCC	Federal Communications Commission
GPS	Global Positioning System
HALE	High Altitude, Long Endurance
JAR-VLA	Joint Aviation Requirements - Very Light Aircraft
MMCU	Mobile Mission Control Unit
MNS	Mission Need Statement
NAS	National Air Space
NASA	National Aeronautics and Space Administration
RF	Radio Frequency
RPV	Remotely Piloted Vehicle
UAV	Unmanned Aerial Vehicle
UAV JPO	Unmanned Aerial Vehicle Joint Project Office
UGV	Unmanned Ground Vehicle
US	United States
USA	United States Army
USACERL	USA Corps of Engineers Construction Engineering Research Laboratory
VHF	Very High Frequency
VOR	VHF Omnidirectional Radio Range
VTOL	Vertical Takeoff and Landing

C.1 PURPOSE

The purpose of this Appendix is to illustrate the dual-use nature of UAVs by describing the ongoing efforts, initiatives, and plans to use UAVs for civil and commercial purposes and to provide an update of events that have occurred since publication of the 1993 UAV Master Plan. In this context, civil applications are those involving non-DoD government agencies (federal, state, and local governments), while commercial applications involve the private sector.

Significant investment is still needed for many civil UAV applications, and the market remains too uncertain for industry to invest by itself in the technology. But dual-use government funding for the fledgling UAV industry can be justified because numerous civil government agencies are potential users of UAVs for a wide variety of missions. The government must also formulate rules for UAV operations and address legal and liability issues.

C.2 NEEDS RATIONALE FOR CIVIL AND COMMERCIAL UAVs

C.2.1 Requirements

Current, developmental, and conceptual UAV systems and missions can, in all likelihood, be extended and transitioned from DoD to meet civil and commercial needs. However, there must be a detailed examination and evaluation of specific applications and their associated operational requirements, as well as the entire conversion process. Several key factors relate to the defense conversion of UAV systems.

Current UAV systems have been driven primarily by military needs, requirements, technological capabilities, cost, and timeliness. Military acquisition of UAVs has focused on central planning, initially from the Services and then from the UAV JPO, to develop and field a few, specialized UAV systems. These systems had to fit into the existing military order of battle, serving primarily as weapons support systems. There was no coordination with peacetime, civil jurisdictions (city and county, state, regional, national, and international) and regulations. These systems reflect military definitions of cost/effectiveness, such as performance, survivability, life cycle support, and timeliness.

However, the civil and commercial sectors have their own unique drivers, such as specific civil and commercial applications. There are multiple jurisdictions and organizations establishing UAV needs, priorities, and regulations. Multiple user applications, needs, requirements, and roles exist, as well as different cost/benefit issues.

Competing, operational, nonmilitary systems that might satisfy some of the requirements for UAVs include manned aircraft, balloons, rockets, satellites, towers, and buoys.

The UAV JPO will facilitate a smooth transition of UAV systems, through defense conversion, into the civil and commercial sectors by:

- Serving as a central information source and coordinator to assist potential civil and commercial users in evaluating UAV capabilities for their specific applications and operational requirements
- Facilitating a structured dialog to determine the user perspective of the civil and commercial market for UAVs, including their needs, priorities, value, and timeliness
- Developing a process (based on knowledge of technologies and user needs) in which individual user applications and needs can be quickly evaluated in the context of applicable UAV systems and their availability, performance, and cost
- Assisting in evaluating, refining, prioritizing, and synchronizing an orderly transition of candidate UAVs and mission modules into the civil and commercial marketplace by examining costs (development, acquisition, and life cycle cost); economies of scale; modular and reconfigurable multiuse systems, customized around a few robust airframe systems; and interoperability and commonality among and with other military, civil, and commercial systems and components
- Developing synergy and common bonds from potentially diverse interests through UAV JPO sponsored and supported workshops and working groups of military users, potential civil and commercial users, developers, and third-party suppliers to refine systems and initiate fielding of UAVs
- Supporting and subsidizing initial users (through contracts and grants) to rapidly develop, integrate, and deploy high-payoff systems.

The UAV JPO will extend the present military family of UAV systems, through defense conversion projects, as applications and needs of the civil and commer-

cial sectors are surveyed, evaluated, and understood. However, it is expected that many of the currently identified applications of civil and commercial sectors can be satisfied by extending military UAVs and the available mission modules that are currently being developed.

Five high-level operational requirements – endurance, speed, radius of action, altitude, and takeoff gross weight – in large measure specify the physical characteristics of a UAV and its subsystems, including airframe, propulsion, navigation, guidance, communications, command and control, launch and recovery, payloads, and operational interfaces. The latter generally require minimum crew size, ease of training, and simple maintenance and life cycle support systems. In addition, low life cycle (acquisition, operations, and maintenance) costs will have a greater affect on civil and commercial applications.

Analogous to the military MNSs, high-level operational capabilities for civil and commercial UAVs can be examined:

System Management

The operational capabilities of UAVs will be defined, in part, by each UAV's assigned role as part of an organizational structure or hierarchy that responds to specific short- and long-term tasks and that must coordinate with other systems (including other UAVs). Each civil and commercial organization will be responsible for specifying the need and roles for its UAVs, as well as their operation and maintenance.

Application Restrictions

Operational capabilities, besides being defined by UAV subsystems, strategies, and tactics for specific applications, will also be constrained by exogenous variables, including FAA regulations on airspace and Federal Communications Commission (FCC) regulations on communications (such as transmission power and frequencies); regulations by international, national, state, and local governing bodies; man-made obstacles (such as buildings, towers, power lines, and other manned and unmanned aircraft) and threats (such as vandalism, communications noise and jamming, and weapons fire by criminals); and adverse natural environmental factors, including weather, terrain, and visibility.

Air Vehicle

The air vehicle itself will define many of the operational capabilities through its airframe, propulsion, navigation, guidance, and other avionics suites. The performance of the UAV, including endurance, speed, radius of operation, operational altitude, altitude limitations (high and low), takeoff speed and gross weight, recovery speed, power expenditure, and payload will be determined primarily by the type of air vehicle –fixed wing, rotary wing, ducted fan, or blimp – and its size and weight. Propulsion systems, and the associated energy density (from fossil fuels or electric battery/solar cells), will affect flight parameters. Navigation and guidance may include inertial, GPS, long range aircraft navigation, and direct or indirect visual systems, which will strongly influence mission profiles.

DataLink

The datalink should permit UAVs to exchange information with ground stations and other platforms. It may be involved in controlling the UAV and obtaining sensor or status information from the UAV, or it may be the primary payload of the UAV (as for a communications relay). Datalink capabilities will depend upon the mode of operation, whether RF or non-RF. For RF datalinks, two performance measures are throughput and range, which are affected by transceiver bandwidth, power, and many environmental (natural and man-made) factors for signal-to-noise ratio. Non-RF datalinks, which might avoid some problems of overloaded RF channels and potential jamming, can be implemented with laser communications or fiber optic cables (for tethered systems). Various coding and encryption techniques may also be employed.

Launch, Recovery, and Ground Control System

Launch and recovery systems will reflect UAV launch weights and speeds and the usefulness of the UAV system for various applications. Ground stations will include communications and processing equipment to interact with a single UAV (or multiple UAVs and perhaps other related systems). Ground stations may be stationary or mobile on land, at sea, or in the air, depending on the UAV system and its application. Trained crews are needed to operate the user interfaces (computer and mechanical systems) for launch, operation, and recovery.

Payload

The various kinds of sensors, receivers, emitters, cargo, and other payloads a UAV must carry will help determine its design and flight profile and its suitability for various missions. However, in many cases an existing UAV system must accommodate (or be modified to accommodate) various payload modules that were not foreseen during the original design of the UAV. Users may need assistance in matching their payload and mission profile requirements with off-the-shelf UAVs.

Reliability and Survivability

The commercial viability of the UAV is dependent on its ability to perform with-

out catastrophic failure leading to civilian damage or casualties. Quality control, appropriate design, and redundancy can enhance reliability. It must also survive artificial and natural threats. Man-made threats (as from criminals or vandals) can be countered by suitable design and fabrication for stealth (minimizing size, stealthy shape, camouflage paints and coatings), minimizing emissions (acoustic, visible, radar, and infrared), and coding communications. Survivability can be enhanced by selecting appropriate flight profiles, operating distances, and speed.

Natural threats can be countered by carefully monitoring weather and terrain and developing contingency flight plans.

C.2.2 Analysis of Operational Effectiveness and Efficiency

The COEAs performed for military UAVs can be a starting place for analyzing the cost/benefits for civil and commercial systems. The COEA process typically includes: Phase I, a comparison of the performance of missions by UAVs with their performance by the most likely non-UAV alternatives; Phase IIA, a determination of whether one UAV system could substitute for another in a cost-effective manner; Phase IIB, a description of a family of UAVs and missions; and focused COEA, an evaluation of quantity versus quality options for the deployment of UAVs in various circumstances. A generic tradeoff analysis methodology consists of defining objectives and requirements, identifying alternatives, formulating selection criteria, weighting criteria, preparing utility functions, evaluating alternatives, performing a sensitivity check, eliminating sensitivities, selecting preferred alternatives, and executing a decision. The tradeoff analysis may consist of a combination of qualitative and quantitative techniques.

During 1994, the UAV JPO will sponsor a project to evaluate and demonstrate that DoD UAV systems can be applied to various government-wide and paramilitary applications and that civil UAVs are technically and economically feasible. Operations research techniques will be used to estimate the utility (costs/benefits) of potential civil and commercial UAV applications. The project will include: (1) a survey of prospective civil UAV users; (2) a functional analysis to determine key civil UAV systems; (3) a technology forecast to determine if the prospective UAV systems will be available to satisfy the functional requirements; (4) a multivariate decision analysis to define and evaluate measures of merit (effectiveness and efficiency) and to perform tradeoff analyses among the choices for civil UAV systems, subsystems, technology, and applications; and (5) an evaluation and ranking of the prospective systems. Eventually, developers and users may have a computerized database and intelligent decision aid to help them decide whether to use a UAV for a given application and which UAV to select.

C.2.3 Basic Tenets For Civil/Commercial UAVs

The basic tenets of a civil/commercial UAV program are for the UAV JPO to:

- Provide leadership, coordination, and support while serving as an initial focal point and catalyst for assisting industry in developing civil/commercial UAV applications
- Explore and evaluate opportunities and requirements for technology transfer to new user communities
- Provide leadership in technology development and integration, technology transfer, defense conversion regulatory synchronization with the FAA and the FCC, guidance on interoperability and commonality, exploring synergies among various government and private organizations, and developing UAV acquisition strategies for economies of scale
- Serve as a focal point and catalyst for establishing standards, protocols, and specifications to ensure compatibility and open system architectures for interfaces, communications, block upgrades, training, maintenance, replacement, and repair
- Harmonize operational requirements among the military and civil communities and ensure interoperability among UAV systems and subsystems
- Procure and integrate off-the-shelf technologies and commercially available components for initial systems, thereby reducing cost, risk, and duration of development
- Conduct and monitor advanced research and development to enhance future civil, as well as military, UAV system capabilities.

C.3 APPLICATIONS

The remarkable success of UAVs during

Desert Storm gave the world a brief glimpse of their potential. UAV prospects in the US military remain favorable, despite geopolitical changes and reductions in the defense budget. UAVs can take many forms: fixed wing, rotary wing, glider, gyroplane, or ducted fan; heavier-than-air or lighter-than-air; single engine or multiengine; propeller or jet; battery-powered electric, solar-powered electric, microwave-powered electric, gasoline, or diesel. UAVs can be any size, and they are capable of a wide range of performance: from small, hand launched, low-altitude UAVs with a range of 10 km or less to large wing-span, high-altitude, long-endurance UAVs able to traverse the globe. Civil/commercial applications can be performed by any or all of the many UAV forms, although certain applications tend to favor some vehicle and system configurations over others.

Civil/commercial UAVs, regardless of form, perform one or more of the following functions:

- Carry sensors (such as video, infrared, radar, and chemical)
- Carry communications relays
- Carry cargo.

C.3.1 Civil Government Agency Applications

Many federal, state, and local government agencies are potential users of UAVs, including:

- Department of Agriculture
  - Pesticide & fertilizer spraying
  - Insect sampling (bug catching)
  - Farm management
- NASA
  - High-altitude atmospheric sampling (as for ozone)
- Postal Service
  - Package delivery
- Federal Emergency Management Agency
  - Surveying and assessing disaster areas
  - Facilitating relief operations
  - Relaying communications
- Forest Service
  - Area surveillance of forest (plant growth, fire control)
  - Counternarcotics surveillance - mapping
  - Firefighting (carry water or chemicals)
- Weather Service
  - Storm observation, tornado chaser
- Fish and Wildlife
  - River and estuary surveying for illegal hazardous waste dumps
  - Wildlife tracking and accounting in remote areas
  - Mapping
  - Counterpoaching
  - Fishing law enforcement
- DOE
  - Monitoring nuclear facilities
  - Reconnaissance for hazardous waste cleanup
  - Atmospheric and climatic research
- Bureau of Land Management
  - Archeological and fossil surveying and monitoring
  - Hazardous waste dump surveying and monitoring
- Customs
  - Counternarcotics surveillance
- Border Patrol
  - Patrolling, surveying, and controlling borders
  - Counternarcotics and illegal alien surveillance
- FBI
  - Special Weapons and Training support
  - Counternarcotics surveillance
  - Surveillance of suspects
  - Search and rescue
- State and Local Law Enforcement
  - Special Weapons and Training support
  - Riot control
  - Area surveillance, highway patrol
  - Counter narcotics surveillance
  - Search and rescue
- State Department
  - Area security surveillance
- DEA
  - Counternarcotics surveillance
- National Guard
  - Counternarcotics surveillance
  - Riot control
  - Law enforcement support
  - Emergency relief surveys
- Environmental Protection Agency
  - Air sampling
  - Hazardous waste dump surveying and monitoring
- Department of Transportation
  - Traffic and highway surveying and monitoring
  - Mapping
  - Coast Guard (surveillance for counternarcotics, illegal aliens,

illegal fishing, national security threats, search and rescue operations)

- Civil Air Patrol
  - Training cadet UAV pilots

- Merchant Marines
  - Training pilots for commercial maritime UAV operations

- Army Corps of Engineers (Civil Missions)
  - Monitoring recreational areas
  - Surveying for dams, levees, and other construction projects
  - Disaster control.

C.3.2 Commercial Applications

Private sector potential UAV commercial applications include:

- Communication Relay
  - Equivalent to a low-altitude satellite

- Media
  - Overhead cameras for news and special events

- Real estate
  - Pictures for selling property
  - Surveying

- Surveying
  - City and suburban planning

- Farming and Ranching
  - Checking on cattle, fence lines, and work crews
  - Spraying crops with pesticide and fertilizer
  - Monitoring crops, soil, moisture, and pest conditions
  - Insect sampling

- Maritime
  - Monitoring and reconnaissance of fishing areas
  - Monitoring shipping hazards
  - Monitoring shipping disasters
  - Search and rescue

- Security
  - Surveillance

- Delivery Services
  - Overnight package and mail delivery to small towns

- Lumber Industry
  - Tree spotting
  - Tree removal

- Film Industry
  - Aerial photography
  - Special effects

- Archaeology
  - Aerial observation of sites and digs

- Oil and Mineral Industry
  - Gas and oil pipeline monitoring (in desolate areas)
  - Searching for mineral and fossil fuel deposits

- Railroads
  - Aerial monitoring of rail lines
  - Aerial monitoring of trains (operations and accidents).

In support of the defense conversion initiatives, the UAV JPO and DESA, in cooperation with other government agencies, are examining the technology needed to establish two classes of rotary wing UAVs able to perform a variety of civil applications.

The Class 1 UAV would be sufficiently small to fit into one or two foot-locker type cases, with the ground control unit fitting into another case. With a payload weight of 5-10 lbs (2-5 kg) and an endurance of 60 minutes, the UAV could satisfy the following prospective applications:

- Law enforcement

- Environmental monitoring, air sampling of smoke stacks, flying over drainage areas

- Civil inspection of waterways, dams, levees, bridges, buildings, landfills, etc.

- Inspection and monitoring of an accident site involving hazardous material

- Post-disaster area inspection

- Traffic control and monitoring

- Temporary radio relay in mountainous areas

- Range clearance verification

- Quick response to a perimeter in trusion alarm.

The Class 2 rotary wing UAV would be a scaled-up version of the Class 1, having a payload capacity of 20-30 lbs (9-14 kg) and a flight endurance of perhaps 3 hours. It would be suited for:

- Search and emergency supply delivery in rugged/isolated areas

- Extended border patrol response and surveillance

- Forest fire observation and surveillance.

The following subsections expand upon the civil and commercial use of UAVs for law enforcement, meteorological, communications relay, agricultural, environmental, and other purposes.

C.3.3 Law Enforcement

The Pointer Hand Launched UAV has been demonstrated to several police departments in California and elsewhere, as well as the FBI, to favorable reviews. Airspace management and liability issues have deterred implementation. However, the Oregon National Guard used Pointer in more than 12 law enforcement missions during 1993. One mission supported the state police in a drug raid in a very remote area of the state, mapping a strategy for raiding a drug lord's compound. Video imagery of the compound to be raided showed more buildings, cars, dogs, and fences than was suspected. In another operation, Pointer helped the Washington State Gambling Commission observe illegal cock fights. The DEA, which has also flown Pointers loaned by the UAV JPO with satisfactory results, has purchased its own Pointer systems. The DEA version has a new video system that will allow an operator to discern individuals. The need to recognize individuals is an example of a UAV capability that is more important for a civil application than for a military mission.

As an example of an unusual law enforcement application following Pointer flights in 1993, the Bureau of Land Management is considering using Pointer or other UAVs to observe prehistoric Native American ruins in New Mexico. The objective would be to use UAVs to capture poachers of national treasures in sites too difficult for foot or ground vehicle patrols to traverse.

The Counter-Drug Technology Center, which resides in the Executive Office of the President, is examining UAVs for various counterdrug missions. UAVs, for example, could play a significant role in improving covert transmission and processing of data from covert sensors, and serving as relays to enhance communications. To support detection and monitoring functions, the Center suggests that UAVs may need to carry such sensors as compact air search radars; lightweight parabolic microphone listening devices; daytime and low-light-level television with frame grabber; 3-5 micron infrared cameras; lightweight electromagnetic detection systems (passive and active); passive chemical and vapor sniffers; ultraviolet sensors; and lasers. UAV system features desired by the Center include affordability, ease of operation, reliability, low false alarm rate, minimum support, relocatable, covert operations, and high availability.

C.3.4 Meteorological And Atmospheric

As part of the dual-use thrust, NASA is initiating an alliance among government agencies, industry, and nonprofit associations to demonstrate cost-effective high-altitude and/or long-endurance UAVs for atmospheric research. Government agencies expressing interest in joining the alliance with NASA include DoD, DOE, National Oceanic and Atmospheric Administration, Department of Commerce, and the Environmental Protection Agency. The NASA vision is that by the year 2000 this effort would effect the formation of a new US market for civil UAVs. However, the goal of the program is not to develop new UAVs. Rather, industry participants will be expected to have available UAVs suitable for the missions of interest and to demonstrate how well the UAVs and payloads perform those missions. As part of the program, the existing platforms may be modified to enhance performance, as with a new propeller design or propulsion system, or modified to carry a new or different payload. In initial estimates of various configurations, altitudes for participating UAVs might be from 50,000 ft to 98,000 ft, range from 620 nm to 12,427 nm, duration from 4 hours to 96 hours, and weight from 110 lbs to 3,520 lbs. NASA is prepared to spend at least $90 million through 1999 to leverage the development of a $1 billion civil UAV market at the start of the coming millennium. Two thirds of the funding will support UAV flights to gather atmospheric information, while one third will be used to develop atmospheric sensors and associated airborne equipment to exploit the advantages of the UAVs as atmospheric research platforms. At the end of the program, UAVs which were successful will have an advantage in the commercial marketplace.

The US National Meteorological Center (part of the National Oceanic and Atmospheric Administration's National Weather Service) is developing requirements for the use of High Altitude, Long Endurance (HALE) UAVs for monitoring hurricanes and gathering meteorological data over the ocean. Two types of UAVs are being considered. One is a large vehicle, flying at altitudes of 75,000 ft (22,900 m) for up to a week, which would drop sondes into hurricanes and other storms. The other UAV would be smaller and carry sensors on board. It would fly into hurricanes, possibly on long-range, intercontinental meteorological missions. Both UAVs could be preprogrammed or controlled by an operator. The Center is also considering leasing the Boeing Condor HALE UAV. Also, NASA is interested in Condor for atmospheric research. The Atmospheric Radiation Measurement Program of the DOE intends to develop UAVs to probe the tropopause (between the troposphere and stratosphere); the UAVs offer advantages over satellites, balloons, and high-altitude manned aircraft for this work.

C.3.5 Communications Relay

The Skylink Communications Network Corporation, working with the NASA Jet Propulsion Laboratory, ARCO Power Technologies Inc., TRW, Teledyne Ryan Aeronautical, TIW, Varian, and Sunstrand Aerospace, is developing a HALE UAV, powered by a microwave beam, for wireless communications, mobile cellular phones, and direct broadcast television. The UAV can remain at 70,000 ft (21,336m) indefinitely, providing a coverage area of 307,000 sq mi (799,000 sq km). The fixed, ground power transmission station tracks and aims a beam of 35 GHz RF microwave energy at the platform loitering overhead, whereupon rectifying antennas on the UAV convert the beam into hundreds of kilowatts of power to operate the vehicle's propulsion system and communications payload. The UAV has a payload capacity of 770 lbs (350 kg) and 329 cubic ft (9.3 cubic meters). At an estimated cost of $40 million per system, the UAV would be relatively inexpensive compared with the cost of comparable communications coverage from terrestrial microwave tower systems (more than $60 million), or compared with other alternatives, such as geosynchronous satellites ($350-500 million) or low-altitude satellites ($120 million). The size of the market for the system was estimated by Skylink at 40-60 systems worldwide. The company has been funding development of the system with investment capital.

In any event, other types of HALE UAVs, whether solar-powered or gas-powered (and gas-power can provide several days of on-station duration with proper vehicle design) can be used as surrogate satellites for communications applications. With the rapidly expanding use of cellular communications, the HALE UAVs (the equivalent of "low-altitude satellites") could have a major impact.

C.3.6 Agricultural

Arizona Biological Control Inc. has developed and flown a small (5 ft wingspan) UAV designed to disseminate beneficial, predatory insect eggs and bacteria to control farm pests. Instead of taking 8 hours to cover a 50-acre field, the UAV can do the job in 10 minutes. The tiny UAV is the most cost-effective method for dispersing biological controls over fields 50 to 500 acres in size. For fields larger than 500 acres, manned crop dusting aircraft are more cost effective, although larger UAVs might also be a suitable alternative. After a remotely controlled switch opens the UAV's release-pod door, an air-jet nozzle blows and disperses over the field such biological substances as grasshopper pathogens and tricho-gramma and green lacewing eggs. The UAV, with a payload capacity of 2 lbs (0.9 kg), can also be used for timely, judicious, and precise targeting of chemical pesticides. The UAV is remotely controlled within the operator's line of sight, limiting sorties to an area of about 50 acres. The UAV typically flies 15 ft (4.6 m) above the crop canopy at 35 mph (56 kph). Far from being militarily camouflaged, it is painted bright red to enhance its visibility to the operator. The UAV reportedly sells for $2,000 each.

C.3.7 Environmental

IAI Maman Data Systems Center developed Nukeye, a computer system designed to support the deployment of UAVs in monitoring the formation and propagation of radioactive clouds or other pollutants. The system plans optimum routes for the UAV, taking into account topography, terrain cover, meteorological conditions, motion of the UAV, and the expected evolution of the pollutant cloud, and tracks the UAV on digital map displays.

Video and other sensor data transmitted by the UAV can be displayed in the context of the digital maps or other formats, such as charts, drawings, or photographs.

Roy F. Weston Inc., an environmental services company that specializes in environmental remedial investigations, risk assessment, and emergency response, is teaming with IAI to provide unmanned vehicles for environmental applications. In addition to UAVs, unmanned ground vehicles and unmanned surface water vessels, also supplied by IAI, will be used as needed. The UAVs will carry a variety of environmental sensors, including those for video imaging, gas analysis, and radiometric, magnetic, and temperature measurement. The sensors will allow the UAV to detect and locate areas needing environmental response, such as for site assessment, site cleanup, disaster monitoring, and preparing property for transfer. The UAV would be operated from a mobile mission control unit (MMCU) situated outside the surveyed area. The mission would be preplanned by an expert system in the MMCU computer. Information downlinked from the UAV to the MMCU would be presented on digital map displays generated by a geographic information system. Examples of environmental disaster control missions for the UAV include (1) environmental monitoring of reactor sites and other nuclear facilities to determine the distribution of nuclear pollutants in the air and on the ground; (2) immediate data collection during industrial and environmental accidents, such as release of noxious or toxic substances from chemical and metallurgical installations, and monitoring of the sources and distribution of pollution; and (3) damage assessment and

direction of relief activity in the event of natural disasters such as earthquakes, floods, hurricanes, volcanic eruptions, and forest fires.

The USACERL is examining the Pointer Hand Launched UAV for low-altitude environmental assessment applications.

C.3.8 Other

UAVs can carry cargo, although this prospective application has not received much attention yet. For example, the use of UAVs for overnight delivery of mail and packages to towns with populations between 50,000 and 250,000 may be economically feasible. In addition to express mail, the overnight delivery service can be used by small businesses for inventory control, with just-in-time delivery of parts and supplies. The UAV would automatically takeoff, fly, and land. Federal Express has expressed interest in the concept. UAVs are also being considered, by the USA Natick Research Development and Engineering Center, for precision delivery of airdropped cargo in aid operations for Bosnia-type missions.

The California Department of Transportation is experimenting with the Moller Aerobot, a ducted fan UAV, for inspecting bridges. Other studies are examining tethered and free-flying lighter-than-air, helicopters, and ducted fan VTOL UAVs for bridge inspection. There are 600,000 highway bridges and 100,000 railroad bridges in the US, as well as pipeline and utility bridges.

AeroBureau Inc. has a Cyclone UAV (a smaller version of the Pioneer) from AAI Corp. for use in gathering news. AeroBureau features a manned, modified Lockheed Electra that is fully equipped with sensors, computers, and communications electronics to gather and report breaking news anywhere in the world. The UAV would be used when the manned aircraft was parked (although later versions of the UAV could be air-launched), to fly over hazardous areas and gather the news with video and other sensors.

C.4 THE FEDERAL AVIATION ADMINISTRATION AIR SPACE MANAGEMENT INITIATIVE

C.4.1 Introduction

The FAA is establishing new rules governing the operation and flight of UAVs in civilian airspace over the United States. The rules will be needed before a viable civilian/commercial UAV industry can take off. This section describes the basis for the rules, the rule making process, and the various issues under consideration.

Current regulations evolved in parallel with manned aviation technology, without consideration for unmanned flight. Most of the regulation Parts, listed below, only require a change in definition and/or a finding that they apply to UAVs and UAV operators. However, significant changes or additions are needed for Parts 23 (airworthiness standards, airplane), 27 (airworthiness standards, rotorcraft), 65 (pilot certification), and 91 (general, operating and flight rules). The relevant Parts of the code are:

- Part 1: Definitions
- Part 21: Certification Procedures
- Part 23: Airworthiness Standards, Airplane
- Part 27: Airworthiness Standards, Normal Category Rotorcraft
- Part 33: Airworthiness Standards, Engines
- Part 35: Airworthiness Standards, Propellers
- Part 36: Noise Standards
- Part 39: Airworthiness Directives
- Part 43: Maintenance
- Part 45: Identification and Registration Marking
- Part 49: Recording of Titles
- Part 61: Certification of Titles
- Part 65: Certification of Airmen
- Part 67: Medical Standards
- Part 91: General Operating and Flight Rules
- Part 137: Agriculture Operations
- Part 141: Pilot Schools
- Part 145: Repair Station
- Part 147: Aviation Maintenance Schools.

The changes in the FAA rules might include airspace reserved for UAV operations, rights of way and traffic priority for UAVs, launch and recovery locations and facilities, certification for the UGV system (vehicle and ground equipment), and certification for the UGV operator, maintenance crew, instructors, and examiners. The FAA is expected to update existing Parts and publish new Parts as required.

In 1992, the FAA contracted with a law firm to draft a set of UAV rules, which were advertised in the Federal Register in the spring of 1993. Interested parties will be encouraged to provide written information, views, or arguments about the proposed rules, which will be designed to allow for expansion to international rules. When accepted, the proposed rules will

become laws.

C.4.2 Previous Rules

The previous rules under which UAVs were flown in civilian airspace were simple see-and-avoid rules: the remote operator of the UAV must either have direct line-of-sight to the UAV at all times (from ground or chase plane) or he must be able to see 360 degrees around the UAV from video on board the UAV, and the UAV must not interfere with other air traffic.

C.4.3 Historical Background

In 1976, the Chief of the Airspace and Air Traffic Rules Division of the FAA addressed the AUVS, which was then known as the National Association for Remotely Piloted Vehicles , on the FAA regulation of UAVs (then known as RPVs). The FAA considered RPVs as "aircraft" under the Federal Aviation Act of 1958 and Federal Aviation Regulation (FAR) definitions, and also determined that these "aircraft" should be regulated under the provisions of Part 91 (General and Operating Flight Rules) of the FARs. Outside of special-use airspace, provisions must be established for UAV operations in a "see-and-avoid" environment. The key FAA issue was – and is – the ability to control UAVs, to operate them in a safe and orderly manner.

New technology since 1976 promises to permit the safe integration of UAVs into the civilian airspace. Navigation and position-determination can be performed with a high degree of accuracy. And new sensors and control systems will allow a UAV to sense other aircraft entering its airspace and take evasive action in all weather conditions.

C.4.4 Role of the FAA

The FAA was chartered by the Federal Aviation Act of 1958 to "foster the development of civil aeronautics and air commerce in the United States...[giving] full consideration to the requirements of national defense, and of commercial and general aviation, and to the public right of transit through navigable airspace." The FAA is directed to:

- Develop plans for and formulate policy with respect to the use of by rule, regulation, or order the use of navigable airspace under such terms, conditions, and limitations in order to insure the safety of aircraft and the efficient utilization of such airspace
- Prescribe air traffic rules and regulations governing the flight of aircraft, for the navigation, protection, and identification of aircraft, for the protection of persons and property on the ground, and rules for the prevention of collision between aircraft and land or water vehicles, and between aircraft and airborne objects.

Before issuing rules, the FAA requested information on potential civil/commercial UAVs:

- What will be the missions for UAVs in the continental United States?
- What are the flight characteristics of the UAVs?
- Will the UAVs be able to conform to current FAA regulations?
- What will be the airspace requirements for UAVs?

Positive control of the UAV by visual means was deemed necessary in 1976 for collision avoidance between UAVs and manned aircraft. Communication was necessary between the UAV "pilot" and air traffic control. Certain equipment was necessary for UAVs operating in controlled airspace, such as lighted position lights, an operable very high frequency omnidirectional radio range (VOR) or tactical air navigation system, and an operable coded radar beacon transponder.

For UAVs without a see-and-avoid capability, the FAA adopted rules from the Special Military Operations Manual (7610.40). UAV operations, to avoid hazards to other air traffic, must be limited as follows:

- Within Positive Control Area
- Within restricted areas
- Within warning areas
- Accompanied by a chase plane if outside the above areas.

C.4.5 FAA Rule-Making Process

In the 1976 presentation, the FAA outlined the rule-making process, which can be short and simple, or long and complex, depending on the subject:

- A petition from an interested person or a request from the Administration to issue, amend, or repeal a rule is made
- If the petition is appropriate, a study is completed containing all of the options
- When determined and approved by the Office of the Chief Council, with respect to form and legality, a notice of proposed rule-making is issued
- The notice of proposed rule-mak-

ing is then published in the Federal Register and interested persons are invited, within a given time frame, to submit written information, views, or arguments about the proposed rule

- After all the comments and information are considered, an analysis and evaluation is prepared and a rule, if appropriate, is submitted to the FAA for consideration
- If the FAA adopts the rule, it is published in the Federal Register.

C.4.6 UAV FAA Certification Recommendations

In 1992, the Aviation Rule Making Advisory Committee, consisting of individuals from government and industry, considered the questions raised in formulating new regulations for UAVs (or any aircraft and aircraft operation). These include:

- Is the regulation necessary to insure the safety of the flying and general public?
- Does the regulation provide an adequate level of safety?
- Is the regulation in the best interest of the general public?
- Does the regulation create an unreasonable economic burden?

The safety issue depends primarily on technology for the control of UAVs, but also important are the operating procedures designed for UAV applications and the training and competence of the UAV pilots, maintenance, and other UAV personnel – the same considerations as for conventional airlines.

According to the Committee, key issues for UAV civil/commercial operations include:

- UAV operations should be transparent to air traffic control (ATC) operations
- The UAV operator must be able to perform all of the functions critical to navigation and safe control of the vehicle which are normally performed by a pilot
- The UAV operator must normally maintain continuous communications with the remote vehicle
- UAVs are not just a vehicle, but rather a system which includes the vehicle; its remote control facility; its command, control, and communications link; its operator/pilot; federal navigation/communication facilities; and interfaces with the FAA and ATC infrastructures.

The UAV system should be introduced transparently to ATC operations because of the need to minimize the impact to the complex and expensive ATC system. Commercial unmanned operations cannot be implemented in a conventionally incremental way because it involves the introduction of a totally new kind of system. All critical elements of UAV operation, including any changes to manned aircraft and the air traffic infrastructure, must be in place prior to operating an unmanned aircraft in the National Air Space (NAS). The process is easier if the new technology and major capability additions are limited to the UAV. The UAV industry should adapt the UAV system to the existing (or planned) ATC infrastructure – especially to its communications and navigational structure. When operating in controlled airspace, the UAV must be capable of normal VHF radio communications with the ATC by means of the UAV's two-way radios, and it must be able to use existing navigation facilities or their equivalent (such as VOR/Instrument Landing System or GPS).

UAVs should be able to execute directions normally issued by the ATC. This includes directions such as: enter pattern on left downwind to 34 right, stay clear of traffic departing the airport, squawk 2347, climb to FL 240, report on top, or stay clear of clouds. Thus the UAV operator/pilot must be able to see and avoid other traffic, clouds, etc. The operator must be able to select the navigation mode and frequency, and be able to change the route and flight path in real-time in response to direction from the ATC.

UAVs can use transponders to partially satisfy the "see and be seen" requirement for aircraft. Also, since UAVs cannot see other aircraft in the conventional sense, they should incorporate an active collision detection and avoidance capability that is, ideally, independent of the capabilities of the other aircraft. Candidate technologies include radar, infrared, or electro-optical sensors able to locate and track other aircraft. But there are no known, currently available autonomous systems which fully satisfy the need of the UAV to be able to see and avoid collision with other aircraft.

Until machine intelligence permits fully autonomous UAVs to operate safely, the pilot-in-the-loop will be essential for UAV control. The remote operator must be able to use sensors on the UAV to see and avoid other aircraft. He or she must be able to recognize dangerous situations and use human intelligence and reasoning to solve unexpected problems. But current technology does allow the remote

operator/pilot to function in a supervisory role, able to control more than one UAV at a time. The supervisory role reduces reliance on the communication link; momentary loss of the link can be tolerated because it does not result in losing control of the vehicle. It only results in losing the ability to alter the preprogrammed flight path. The UAV, however, would then be flying without the operator's eyes and supervision. The UAV system must have a highly reliable C^3 link and a system able to detect and avoid other aircraft.

The same reliability standards as applied to manned aircraft are applicable to UAVs sharing the air space with manned aircraft, although the critical systems and evaluation criteria for UAVs may differ from those for manned aircraft. For example, the C^3 link or the autonomous control system would be critical systems for the UAV, while the landing gear might be noncritical. The UAV's area of operation would also determine which subsystems are critical. For example, a UAV engine failure over a non populated area would not be a critical failure because the major risk is only to the aircraft. But if the engine were to fail over a city, people and property below would also be at risk; the failure would then be critical. UAV propulsion systems which are certified for flight over densely populated areas must be extremely reliable. In general, certification standards for UAV engines, propellers, and essential components, and for their maintenance and repair, would be required for UAV operation in the NAS.

The Committee recommended that UAV avionics include a radar transponder and a traffic alert and collision avoidance system, or their equivalent (smaller and inexpensive systems are needed for smaller UAVs). These would be required standard equipment for most UAVs, even though they are required on manned aircraft only for certain operations. These subsystems would satisfy the "see and be seen" criteria. VHF communications and VOR/Instrument Landing System would also be required for UAV operations in the NAS. Unique avionics that would be required for UAVs include highly reliable autopilot, C^3 link, remotely controlled radios, flight termination system, and autonomous control system.

UAVs can take many forms: fixed wing, rotary wing, glider, gyroplane, or ducted fan; heavier-than-air or lighter-than-air; single engine or multiengine; propeller or jet; electric battery-powered, solar-powered electric, microwave-powered electric, gasoline, or diesel. UAVs can be any size, and they are capable of a wide range of performance: from small, hand-launched, low-altitude UAVs with a range of 10 km or less to large wing-span HALE UAVs able to traverse the globe. The size and operational performance of the UAV are the most important features which affect the risk to manned aircraft and people on the ground. A small, hand-launched UAV, for example, might weigh about 3 kg and could fall on a person's head without much injury. To account for this variable risk, the Committee recommended a taxonomy for civil/commercial UAVs consisting of four UAV classes, as shown in Table C-1 below. UAVs should be registered, as are manned aircraft, to allow the UAV to be identified and the owner traced, if needed, for compliance with regulations and laws.

C.4.7 Responses to FAA Questions

The Aviation Rule Making Advisory Committee, in 1992, responded to questions from the FAA concerning regulations for UAVs. The Committee suggested using the term "remotely piloted aircraft" rather than UAV, in the proposed regulations. They recommended that the regulations and certifications account for the total UAV system: the air vehicle; the C^3 link(s); and the controller(s).

The Committee suggested that the UAV be aware of its situation out to four miles in all weather, and that it have flight control software for collision avoidance when it flies above 500 feet altitude (above local terrain) and beyond line-of-sight of the controller. Fully autonomous (sensor-dependent) flight was deemed premature by the Committee. But automatic, preprogrammed, or supervised autonomy, with carefully specified time, space, and velocity constraints, is considered safe and compatible with the new air

TYPE	WEIGHT	SPEED	ALTITUDE	SYSTEM COMPLEX	CONTROL LINK
Class 1 (Very Light)	< 50 lbs	< 100 kts	< 10,000 ft	Simple	Local < 20 miles
Class 2 (Light)	< 200 lbs	< 150 kts	< 18,000 ft	Simple	Local < 40 miles
Class 3 (Medium)	< 12,500 lbs	< 250 kts	< 60,000 ft	Moderate Complex	May Be Relayed
Class 4 (Heavy)	> 12,500 lbs	Cruise > 250 kts	< 60,000 ft	Complex	May Be Relayed
Class 5 (Lighter-Than-Air)	NA	< 100 kts	< 18,000 ft	Simple to Complex	Local < 40 miles

Table C-1. Possible Taxonomy For Civil/Commercial UAVs

traffic control system. A single ground controller could supervise the flight of several UAVs. With respect to nomenclature, the Committee recommended that the ground controllers or operators be called "pilots," to indicate a higher level of skill requirements than otherwise might be assumed, and medical certification for UAV pilots should be the same as that for conventional pilots. Another nomenclature recommendation: based on the prevailing customs of the air traffic control community, UAVs should be classified as aircraft, not as vehicles, when they operate in civilian airspace. UAVs requiring commercial airfields should be permitted to operate from any commercial airfield, except the busiest pacing airports in the NAS (of which there are 22), according to the Committee.

C.4.8 Recent Events

The UAV Working Group of the Aviation Rulemaking Advisory Committee, consisting of more than 40 volunteers from government and industry, has been meeting regularly to discuss rules for UAV operations in NAS. The FAA asked the Group to prepare an advisory circular to assist the administration in writing rules for UAVs. The Group asked the FAA for clarification and guidance in their task of drafting rules for commercial UAV operations. The FAA responded that it did not have sufficient historical or current information to support UAV rulemaking actions. The advisory circular, which is nonregulatory and recommends operating practices and general guidelines for operations, would address air vehicle design, operator qualifications and training, operations in the national airspace system, interfacing with air traffic control, navigation equipment requirements, and use of "special use airspace" for prototype and procedures testing.
The aircraft certification service recommended that design and structure requirements for UAVs should follow guidance contained in Part 23 (Airworthiness Standards, Airplane), Part 27 (Airworthiness Standards, Normal Category Rotorcraft), Part 33 (Airworthiness Standards, Engines), and Part 35 (Airworthiness Standards, Propellers). However, the UAV Working Group suggested that the guidance contained in the Joint Aviation Requirements for Very Light Aircraft (JAR-VLA) would be more appropriate in most cases.

The Working Group characterized UAVs as follows: "UAVs are capable of flight beyond line of sight under remote or autonomous control. They are not operated for sport or hobby. UAVs never transport passengers or crew."

With the JAR-VLA as a basis for UAV structural design, the Working Group identified UAV critical systems as:

- Navigation
- Flight Control
- Flight Termination
- Communications/Datalink
- Power Plant (applicable to very light aircraft)
- Electrical
- Control Station.

In 1994, a subgroup of the Working Group will be reviewing Parts 21 (Certification Procedures), 23 (Airworthiness Standards, Airplane), and the JAR-VLA to determine how they might affect UAV design for civil/commercial applications. Other committees are examining the frequency allocation problem. The frequency domain is crowded, and video requires extensive bandwidth, which is scarce at lower frequencies. Higher frequencies for UAVs, as in the millimeter waveband, would also permit smaller antennas. The interference problems associated with higher frequencies can be nearly eliminated with spread spectrum techniques.

The Central European Aerospace Coordinating Committee is also examining commercial UAV regulations and is following FAA progress.

ACRONYMS (Appendix D)

DARO	Defense Airborne Reconnaissance Office
DPM	Deputy Program Manager
HAE	High Altitude Endurance
JPO	Joint Project Office
MAE	Medium Altitude Endurance
OSD	Office of the Secretary of Defense
PEO(CU)	Program Executive Officer, Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project
PM	Program Manager
TRUS	Tilt Rotor UAV System
UAV	Unmanned Aerial Vehicle
UAV JPO	Unmanned Aerial Vehicle Joint Project Office
USA	United States Army
USMC	United States Marine Corps
USN	United States Navy
VLAR	Vertical Launch and Recovery
VLC	Very Low Cost

NAME	TITLE	PHONE
	OSD	
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Mr. B.L. Dillon	Director, UAV JPO & Deputy PEO(CU)	703-604-0860
COL R.L. Duckworth	Deputy Director UAV JPO	703-604-0860
CAPT A. Rutherford, USN	Director, Joint Systems Engineering and Analysis/PM MAE UAV	703-604-0918
Mr. R. Glomb	Director, Joint Projects and Demonstrations/PM Pointer Hand Launched UAV, TRUS & VLAR	703-604-1182
Vacant	Director, Joint Testing and Evaluation	703-604-1295
Dr. R.L. Eddings	Director, Joint Logistics	703-604-1185
LtCol K.L. Moore, USAF	Director, Joint International Programs	703-604-1325
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LtCol J.M. Yencha, Jr., USMC	VLC UAV Program Manager	703-640-2079

The UAV JPO strives to continuously improve the quality of the Master Plan. Your contributions to this process are solicited. Please help us by responding to the questionnaire below and mail, telefax, or E-mail it to:

Mr. Robert Glomb, PEO(CU)-UP
Program Executive Officer
Cruise Missiles Project and
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If you would like to be added to a mailing list for the Master Plan, please provide your name, organization, and address.

1. Is the Master Plan responsive to your needs and those of your organization?

2. Does the Master Plan clearly portray the acquisition strategy for unmanned aerial vehicles?

3. What additional topics should be addressed in the Master Plan?

4. Is there any material in the Master Plan that should be deleted?

5. How can we improve the Master Plan?

ACRONYMS (Appendix F)

C&I	Commonality and Interoperability
MPCS	Mission Planning and Control Station
NBC	Nuclear, Biological and Chemical
RPV	Remotely Piloted Vehicle
RSTA	Reconnaissance, Surveillance and Target Acquisition
UAV	Unmanned Aerial Vehicle
USA	United States Army

Commonality - A quality that applies to material or systems: (a) possessing like and interchangeable characteristics enabling each to be utilized, or operated and maintained, by personnel trained on the others without additional specialized training, (b) having interchangeable repair parts and/or components, (c) applying to consumable items interchangeably equivalent without adjustments. Commonality is a life cycle cost decision.

Conventional Standoff Weapon - An unmanned, surface attack, powered or unpowered ballistic missile, semiballistic missile, cruise missile, or UAV having an explosive or otherwise lethal nonnuclear warhead and having an effective operational range exceeding five nautical miles from its lowest operational launch altitude. USA deep fire systems are considered standoff weapons, but USA artillery and artillery-like close fire systems are not.

Family - The set of UAV systems that maximizes C&I.

Interface - A boundary or point common to two or more similar or dissimilar command and control systems, subsystems, or other entities against which or at which necessary information flow takes place.

Interoperability - The ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together. Interoperability is an operational requirement.

Remotely Piloted Vehicle (RPV) - An unmanned vehicle capable of being controlled from a distant location through a communications link. It is normally designed to be recoverable. A nonautonomous UAV.

Subsystems - The major elements of a UAV, including air vehicle, MPCS, mission payload, data link, launch and recovery, and logistics support.

Unmanned Aerial Vehicle (UAV) - A powered aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload. Ballistic or semiballistic vehicles and artillery projectiles are not considered UAVs.

Lethal UAV - A UAV, normally autonomous and expendable, that carries a payload used to attack, damage, and/or destroy enemy targets.

Nonlethal UAV - A UAV that does not carry a payload for physical damage and/or destruction of enemy targets. A nonlethal UAV carries payloads for missions such as RSTA; target spotting; command and control; meteorological data collection; NBC detection; special operations support; communications relay; and electronic disruption and deception. In the context of this document the term "UAV" is equivalent to the term "nonlethal UAV."

ACAT	Acquisition Category
ACTD	Advanced Concept and Technology Demonstration
ADM	Advanced Development Model
ADT	Air Data Terminal
AMGSS	Air Mobile Ground Security System
APU	Auxiliary Power Unit
ARPA	Advanced Research Projects Agency
ATC	Air Traffic Control
ATWCS	Advanced Tomahawk Weapons Control Station
AUVS	Association for Unmanned Vehicle Systems
BDA	Battle Damage Assessment
C^2	Command and Control
C^3	Command, Control, and Communications
C^3I	Command, Control, Communications and Intelligence
C^4I	Command, Control, Communications, Computers and Intelligence
C&I	Commonality and Interoperability
CAG	Common Avionics Group
CARS	Common Automatic Recovery System
CARS-P	Common Automatic Recovery System-Prototype
CAX	Combined Arms Exercises
CDL	Common Data Link
CDR	Critical Design Review
CEP	Concept Evaluation Program
CM	Configuration Management
CMIS	Configuration Management Information System
COEA	Cost and Operational Effectiveness Analysis
COMINT	Communications Intelligence
COMM	Communications
COMOPTEVFOR	Commander, Operational Test and Evaluation Force
CONOPS	Concept of Operations
COTS	Commercial-off-the-Shelf
CR	Close Range
CSC	Conventional Systems Committee
CV	Aircraft Carrier
CVN	Nuclear CV
DAB	Defense Acquisition Board
DARO	Defense Airborne Reconnaissance Office
DEA	Data Exchange Agreement
DEA	Drug Enforcement Agency
DESA	Defense Evaluation Support Activity
DIS	Distributed Interactive Simulation
DoD	Department of Defense
DOE	Department of Energy
DOF	Degrees of Freedom
DPM	Deputy Program Manager
DSI	Defense Simulation Internet
DT	Developmental Test
DT&E	Developmental Test and Evaluation
DUSD(AT)	Deputy Under Secretary of Defense for Advanced Technology
DUTC	DoD UAV Training Center
DWBL	Dismounted Warfighting Battlespace Lab
ECM	Electronic Countermeasures
EIP	Engine Improvement Program
ELINT	Electronics Intelligence
EO	Electro-Optical
EOA	Early Operational Assessment
ESM	Electronic Support Measure
EW	Electronic Warfare
EXCOM	Executive Committee
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FAST	Fleet Assistance Support Team
FBI	Federal Bureau of Investigation
FCC	Federal Communications Commission
FCT	Foreign Comparative Testing
FFG	Guided Missile Frigate
FLIR	Forward Looking Infrared
FLOT	Forward Line of Own Troops
FMS	Foreign Military Sales
FY	Fiscal Year

GCS	Ground Control Station
GDT	Ground Data Terminal
GFE	Government Furnished Equipment
GOTS	Government-off-the-Shelf
GPS	Global Positioning System
HAE	High Altitude Endurance
HALE	High Altitude, Long Endurance
HFE	Heavy Fuel Engine
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HSI	Human Systems Integration
HQDA	Headquarters Department of the Army
IFF	Identification, Friend or Foe
ILS	Integrated Logistics Support
IMINT	Imagery Intelligence
IMU	Inertial Measurement Unit
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
IR	Infrared
JAR-VLA	Joint Aviation Requirements Very Light Aircraft
JDF	Joint Development Facility
JEWC	Joint Electronic Warfare Center
JFC	Joint Force Commander
JII	Joint Integration Interface
JL-COE	Joint Logistics Center of Excellence
JL-MIS	Joint Logistics Management Information System
JLA	Joint Logistics Assessment
JLAWG	Joint Logistics Assessment Working Group
JLSC	Joint Logistics Systems Center
JORD	Joint Operational Requirements Document
JPO	Joint Project Office
JROC	Joint Requirements Oversight Council
JRTC	Joint Readiness Training Center, Ft. Polk, LA
JTC/SIL	Joint Technology Center/Systems Integration Laboratory
JTF	Joint Task Force
JT UAV	Joint Tactical UAV
JUAVT	Joint UAV Team
JULMT	Joint UAV Logistics Management Team
JULWG	Joint UAV Logistics Working Group
LAMPS	Light Airborne Multipurpose System
LHD	Landing Helicopter-Dock
LPD	Landing Platform-Dock
LRIP	Low Rate Initial Production
LSA	Logistics Support Analysis
LUT	Limited User Test
MAE	Medium Altitude Endurance
MAGTF	Marine Air-Ground Task Force
MAVUS	Maritime VTOL UAV System
MCCDC	Marine Corps Combat Development Command
MER	Manpower Estimate Report
MET	Meteorological
MIAG	Modular Integrated Avionics Group
MICOM	Missile Command
MIL-STD	Military Standard
MMCU	Mobile Mission Control Unit
MMP	Modular Mission Payload
MNS	Mission Need Statement
MOA	Memorandum of Agreement
MORR	Maturation and Operational Risk Reduction
MPCS	Mission Planning and Control Station
MR	Medium Range
MS	Milestone
MSL	Mean Sea Level
MST	Manned Surrogate Trainer
MWBL	Mounted Warfighting Battlespace Lab
NAS	National Air Space
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NAWC-AD	Naval Air Warfare Center - Aircraft Division
NBC	Nuclear, Biological and Chemical
NGB	National Guard Bureau
NNAG	NATO Naval Armaments Group

NRaD	Naval Command, Control, and Ocean Surveillance Center RDT&E Division
NSA	National Security Agency
NTC	National Training Center, Ft. Irwin, CA
ONR	Office of Naval Research
ONS	Operational Need Statement
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OT	Operational Test
OT&E	Operational Test and Evaluation
OTA	Operational Test Agency
P^3I	Pre-Planned Product Improvement
PE	Program Element
PEO	Program Executive Officer
PEO(CU)	Program Executive Officer, Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project
PEO(IEW)	Program Executive Officer, Intelligence and Electronic Warfare
PICA	Primary Inventory Control Activity
PM	Program Manager
PS	Prototype Ship
PSEMO	Physical Security Equipment Management Office
RADIAC	Radioactivity Detection, Indication, and Computation
RAM	Reliability, Availability, and Maintainability
RATO	Rocket Assisted Takeoff
RCS	Radar Cross Section
RDEC	Research, Development and Engineering Center
RDT&E	Research Development Test and Evaluation
RF	Radio Frequency
RFI	Request for Information
RFP	Request for Proposal
RPV	Remotely Piloted Vehicle
RSTA	Reconnaissance, Surveillance and Target Acquisition
SAR	Synthetic Aperture Radar
SBIR	Small Business Innovation Research
SCSI	Ship Combat System Integration
SDT	Ship Data Terminal
SEEP	Scientist and Engineer Exchange Program
SIF	System Integration Facility
SIGINT	Signals Intelligence
SIL	Systems Integration Laboratory
SR	Short Range
SSG	Special Study Group
STV	Surrogate Teleoperated Vehicle
T&E	Test & Evaluation
TEMP	T&E Master Plan
TET	Technical Evaluation Test
TRADOC	Training and Doctrine Command
TRSS	Tactical Remote Sensor System
TRUS	Tilt Rotor UAV System
TTSARB	Technology Transfer Security Assistance Review Board
UAV	Unmanned Aerial Vehicle
UAV JPO	Unmanned Aerial Vehicle Joint Project Office
UGV	Unmanned Ground Vehicle
UGV JPO	Unmanned Ground Vehicle Joint Project Office
UHF	Ultra High Frequency
US	United States
USA	United States Army
USACERL	USA Corps of Engineers Construction Engineering Research Laboratory
USAF	United States Air Force
USD(A)	Under Secretary of Defense (Acquisition)
USMC	United States Marine Corps
USN	United States Navy
VHF	Very High Frequency
VLAR	Vertical Launch and Recovery
VLC	Very Low Cost
VOR	Very High Frequency Omnidirectional Radio Range
VTOL	Vertical Takeoff and Landing
WTI	Weapon Tactics Instruction
ZEOP	Z-Electro-Optical Payload